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THE GYPSUM INDUSTRY IN NOVA SCOTIA
PRESENT STATUS AND FUTURE PROSPECTS

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PREFACE

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FOREWORD

This investigation aimed to provide an evaluation of Nova Scotia's gypsum industry and, in particular, a comprehensive description of the entire wallboard industry.

In the course of the project, the Nova Scotia gypsum producers all expressed concern over the potential effect on their markets of chemical gypsum, especially gypsum from flue gas desulphurization treatment. Moreover, preliminary examination of desulphurization systems indicated that this concern might be well placed. Therefore the examination of that area was intensified somewhat in hopes of providing a definitive answer. However, such an answer could not be established because political rather than economic considerations will determine the use of chemical gypsum.

It is interesting that this conclusion, that chemical gypsum is unlikely to replace the natural rock, may be of distinct concern to conservationists. If no natural market exists for gypsum from flue gas desulphurization, such sales will merely represent the least unsatisfactory method for disposing of that undesirable product. They will offer no incentive for desulphurization.

It also became clear in due course that the European market would not be a practical target for a Nova Scotia wallboard. Moreover, because the cost of transportation of wallboard from a plant to the market is the dominant cost feature of the industry, a full analysis of a Nova Scotia potential cannot be made by the Nova Scotia government or even by a local producer of gypsum rock. Only the wallboard producers can do the full evaluation for the markets that

they examine. As a result, the Nova Scotia government role will be limited, more or less, to that of an observer of the game who may or may not be able to encourage the players; assuredly, the province will neither make the rules nor control the play.

Numerous organizations and individuals assisted in this investigation and we wish to register our sincere appreciation, especially to those who went out of their way to do so. We make particular note of the open cooperation of the wallboard producers who convinced us of their wish to have the nature of the industry clearly set out.

The following organizations made significant contributions to the work: Domtar Construction Limited, United States Gypsum, Little Narrows Gypsum Limited, Fundy Gypsum Limited, National Gypsum (Canada) Limited, Georgia Pacific Corporation, Ontario Hydro Electric Power Commission, Tampa Electric Company, Florida Phosphate Research Institute, Atlantic Sea Lines Limited, Upper Lakes Shipping International, federal Departments of Energy, Mines and Resources and Regional Industrial Expansion, Statistics Canada, and the Ontario Ministry of the Environment.

Especially, too, we wish to acknowledge the personal contributions of Mr. P. Wilson, Department of Regional Industrial Expansion; Mr. D.G. Stonehouse, Department of Energy, Mines and Resources; Ms. Sharon M. Foyer, Statistics Canada; and Mr. Jean Pressler, U.S. Department of the Interior.

We also record that the opinions in this report are ours alone.

Jim H. Brown

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EXECUTIVE SUMMARY

The primary purpose of this investigation was to review the gypsum industry in Nova Scotia from the standpoint of its current status and future prospects. The authors interpreted the intent of the Government of Nova Scotia in commissioning the investigation to be one of assessing the strength of the industry now and identifying any future employment or revenue generating opportunities.

The investigation was conducted over a period of ten months. An extensive literature review was completed and meetings and interviews were held with commodity specialists in both the U.S. and Canadian Governments, various transportation companies and agencies, officials of foreign embassies in Ottawa, producers of by-product gypsum, officials at Canadian Embassies, High Commissions and Consular Offices overseas and with senior officers of the four largest gypsum wallboard manufacturers in North America.

Nova Scotia has gypsum deposits of high purity that are located close to tidewater and these factors have been instrumental in the development of the industry. These factors alone are no longer sufficient to guarantee a continued demand for gypsum from Nova Scotia. For example, gypsum from Spain is of comparable quality and the existence of extremely low cost "back haul" transportation to ports on the eastern seaboard of the United States makes it highly competitive with gypsum from Nova Scotia. Any increase in the landed price of Nova Scotia gypsum in the U.S. could be expected to result in a shift in demand away from Nova Scotia to other sources such as Spain.

One of the initial hypotheses of the investigation was that by-product gypsum (obtained from the production of phosphoric acid and from flue gas desulphurization) posed a threat to natural gypsum in the major area of consumption, gypsum wallboard production. This threat was considered to be a major one because of expected further legislation controlling sulphur dioxide emissions. Both major types of by-product gypsum were found to be unsuitabe for use in wallboard production, although they can be added in small proportions to a natural gypsum slurry. Their unsuitability stems from the existence of impurities and from certain physical characteristics which make them unsuitable for use as a sole input to a wallboard production process. The costs of removing these impurities or changing the physical characteristics are currently in excess of the costs of producing natural gypsum. Any decision to use by-product gypsum in wallboard production will therefore be based upon other than economic considerations.

Over 70% of the gypsum consumed in North America is used in wallboard production. This figure is higher for gypsum from Nova Scotia, and hence any examination of Nova Scotia gypsum markets must be done almost totally within the context of wallboard markets. Because of population demographics in North America (reduced birth rates and stabilizing population levels) and concurrent projections of housing starts and new construction, the future market for wallboard is expected to remain stable rather than grow. As a result, increased levels of mining of gypsum in Nova Scotia are unlikely in the future. Future emphasis must therefore be on cost control and the protection of existing markets.

A major focus of the investigation was the feasibility of the establishment of a gypsum wallboard production facility in Nova Scotia. It was

clear from the outset that the demand for wallboard in the Atlantic Provinces was insufficient to support an economic scale plant and external markets would have to be found. Although large markets for wallboard were identified in Japan and Western Europe, it was concluded that because of transportation costs and other non-tariff barriers neither of these markets represented a feasible prospect for a Nova Scotia plant. Any plant built in Nova Scotia would have to be justified on the basis of the market in the Eastern United States.

Gypsum is currently mined in Nova Scotia and shipped aboard bulk carriers to production facilities located on tidewater on the eastern seaboard. Wallboard can be shipped approximately 300 km from a production facility before road transportation costs completely consume profit. The investigation therefore focussed on identifying a transportation system that could move finished wallboard from Nova Scotia to the east coast of the U.S. at a per ton rate comparable to that for the bulk raw gypsum. If such a means could be found, a single plant in Nova Scotia could compete with all plants on the east coast of the U.S., assuming production costs in Nova Scotia are comparable to those in the United States.

Such a transportation system was identified. However final judgement on its feasibility must be based upon analyses conducted by individual firms using corporate cost data not available to the authors. The transportation system involves the use of off-road low cost "MAFI" trailers and dedicated roll-on, roll-off (RoRo) vessels. It was possible to confirm that a bulk density approaching that for raw gypsum aboard a bulk carrier is possible for wallboard using MAFI trailers and dedicated, designed-for-purpose RoRo vessels. As well, loading and unloading rates for wallboard aboard MAFI trailers can easily exceed what is possible with the

bulk gypsum. It was concluded that since loading and unloading rates were comparable on a cost and ton per hour basis and since similar bulk densities for wallboard versus raw gypsum could be achieved aboard ship, then a good case could be made for an economic scale wallboard plant in Nova Scotia.

Because the market for wallboard is expected to remain stable, any new wallboard facility in Nova Scotia would have to be justified on some grounds other than market growth. Some scenarios that were considered included the replacement of outdated or uneconomic facilities, the construction of a facility to produce wallboard for one of the emerging specialty markets (for example, water resistant wallboard) or the entry of a firm that planned to increase its market share on the east coast.

There does appear to be a basis for discussing the establishment of a gypsum wallboard production facility in Nova Scotia with one of the existing North American manufacturers. It is recommended that copies of this report be made available to interested firms and that they be invited to carry out their own cost analyses.

Chapter I INTRODUCTION

Section I-1 Nova Scotia Gypsum

Gypsum has been used as a construction material for some three thousand years. In all likelihood it was used initially because it was a soft exposed rock that could be cut and shaped with the available tools. The softness, stability, ease of calcination and rehydration, colour, availability, and noncombustibility which accounted for the early architectural uses of gypsum as a cement and in decorative carving still account for the bulk of its contemporary value. Only the manner in which it is used has changed.

Use of calcined and rehydrated gypsum has been standard practice in interior decoration over the past one or two centuries. Cast decorations were generally either less expensive or were practical replacements for carved wood and stone for the ornate styles of a century or so ago, and the 'plastered' or masonry wall became the norm of high quality construction. Both required skilled craftsmen, however, and that feature plus changing tastes and styles of construction account for the current use of gypsum in contemporary wallboard.

Although immensely useful to construction, both now and in the past, the wide-spread availability of gypsum and its low strength compared to limestone, sandstone, and marble, prevented its becoming a major trading commodity. On the other hand, the recent development of wallboard as a construction material has resulted in a major industry but not a world-wide phenonmenon. Instead, wallboard is primarily produced and used in

the developed world where not just gypsum but speciality paper production and transportation systems also exist. Moreover, where low-cost labour is available, the benefits of wallboard over masonry construction are limited. In short, contemporary gypsum trade and the wallboard industry are focused primarily in Europe, North America, and Japan, although as construction technology of these areas is exported, so is the use of wallboard.

Gypsum is also used in numerous other industries, especially cement and agriculture. However, these outlets account for only a small portion of the total production of the rock. On the other hand, gypsum is also a by-product of several major industries and continued domination of natural material cannot be assumed. In particular, the gypsum that may be produced in the process of removing sulphur from stack gases of coal-burning processes may alter the pattern radically.

As in the case of coal, gypsum has been mined in Nova Scotia since the middle of the eighteenth century. Historical and production records prior to 1833 are limited but it is clear that agricultural use of the mineral dominated its early trade not only in Nova Scotia but in New England and southern states as well.(1)

In fact, trade in gypsum featured in the House of Commons debates in London as early as 1808 and was also a factor in east coast smuggling operations between the, now, Atlantic provinces and the United States in the early 1800s. As a result of agriculture markets, the plaster business, and smuggling, the price of the rock rose to $13 per ton at one point, clearly establishing the heyday of the commodity.

References are given at the end of each chapter.

The development of the gypsum industry was slow, however, probably because of the limited capacity to transport bulk rock and the limited population of the provinces.(2) Though gypsum was readily available and easily mined, transportation systems of the early 1800s were not suited to movement of large tonnages of rock; land transport by rail had not been established and shipping under sail was not a high-tonnage business. Contemporary gypsum trade only began when rail and steam-powered ocean transport became the norm. This pattern is shown in Table I-1-A which shows that production generally was less than a million tons per year prior to World War II.

Following World War II, the industry expanded. Recent production patterns for the sources relevant to this study are shown in Table I-1-B; Nova Scotia production accounts for over 70% of Canadian production, most of which is shipped to the United States. Current production levels in Nova Scotia are close to 6 million tons per year.

The major factors in the growth of the industry have undoubtedly been: the adoption of wallboard, a sandwich of gypsum between outer layers of smooth-surfaced paper which provides a low-cost finished surface for residential and office construction; and the availability of low cost ocean transport for bulk gypsum which permits wallboard manufacture close to the consuming market. Currently 90% of Nova Scotia gypsum exports are used in wallboard manufacture in the United States; the balance is used in the cement industry, with minor amounts consumed in agricultural and other applications.

Former and current mining operations in Nova Scotia are shown in Figure I-1-1, along with the identities of current operators.(5) It is noteworthy that this list of operators is small and that their production

Table I-1-A

EARLY NOVA SCOTIA GYPSUM PRODUCTIONS

Year	Approximate Annual Production (Tons)
1872	100,000
1872 to 1905	100,000 to 200,000
1913	409,800
1918	49,365
1928	971,736

Table I-1-B

POST WORLD WAR II GYPSUM MINE PRODUCTION OF GYPSUM FOR NOVA SCOTIA, CANADA AND UNITED STATES

Year	Reported Production (thousand tons)		
	Nova Scotia[a]	Canada[a]	United States[b]
1945	-	840	3,812
1946	-	1,811	5,629
1947	2,138	2,497	6,208
1951	3,190	3,803	8,666
1955	3,839	4,668	10,684
1959	5,036	5,879	10,900
1963	4,910	5,955	10,388
1967	3,757	5,175	9,393
1971	4,890	6,702	10,418
1973	6,178	8,389	13,558
1975	3,895	5,719	9,751
1977	5,079	7,234	13,390
1979	5,613	8,098	14,630
1980	4,988	7,336	12,376
1981	4,993	7,025	11,497
1982	4,480	5,987	10,538
1983	5,397	7,507	12,884
1984	6,461P	8,725P	-

[a] Canadian Minerals Yearbook, Annual Issues.

[b] U.S. Department of the Interior, Minerals Yearbook, Annual Issues.

P Preliminary data

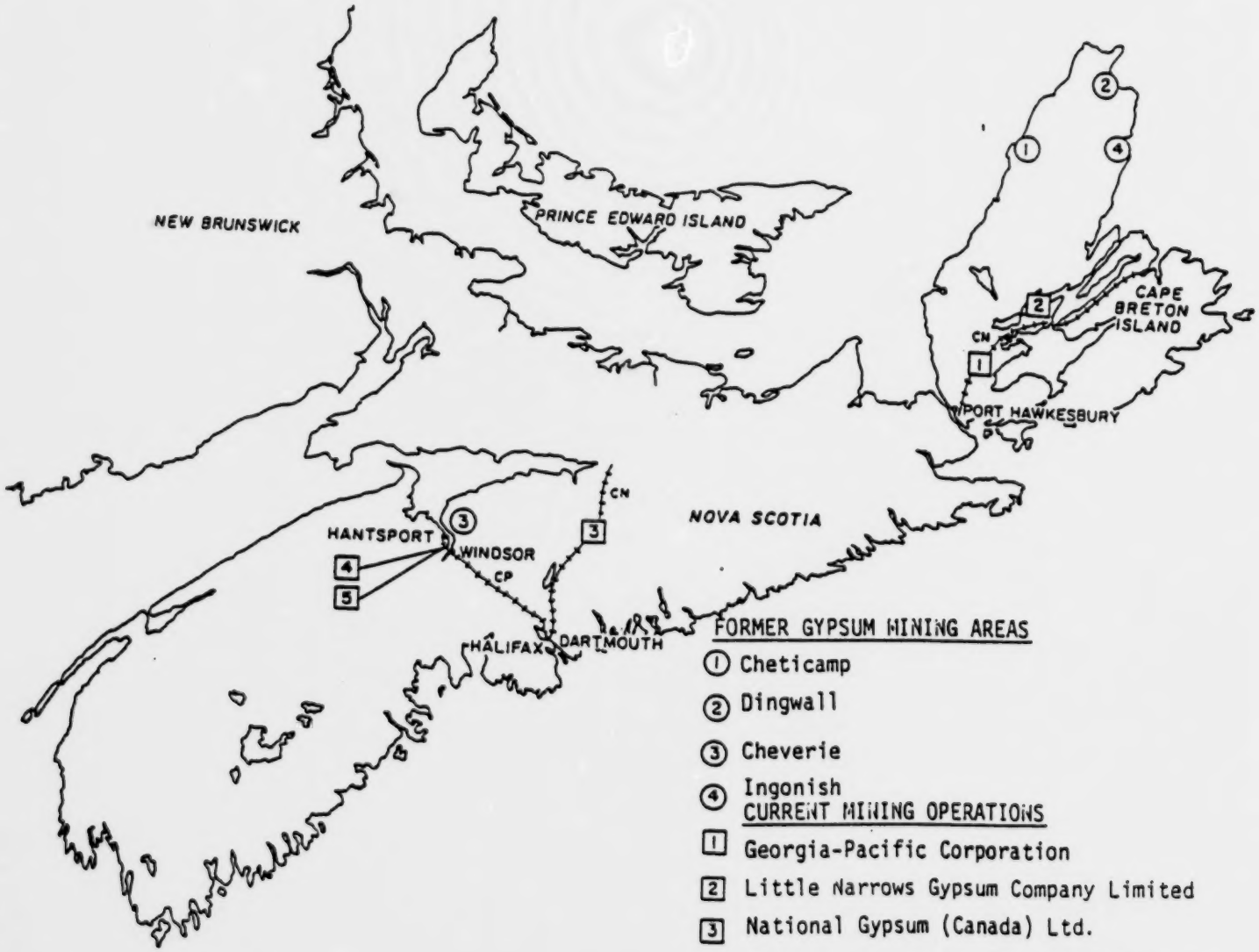

FIGURE I - 1 - 1 - LOCATIONS OF FORMER TYPSUM MINES AND OWNERSHIP OF CURRENT NOVA SCOTIA OPERATIONS (5).

accounts for a major portion of the United States wallboard industry, especially near the Atlantic coast. In fact, the vertical integration of the industry that is suggested by these features is an important element in its operation and one that bears heavily on the opportunities and requirements available to Nova Scotia. The point is emphasized by the map in Figure I-1-2 which shows wallboard plant locations in Atlantic U.S.A., where there are only two gypsum mines now operating, one near Buffalo N.Y. and one near the western limit of Virginia.

It is significant, too, that title to gypsum deposits in Nova Scotia is associated with surface rights, rather than mineral rights.(6) That gypsum is not treated as a mineral resource in the province is probably attributable to the early predominance of agricultural uses of the rock and to the accessibility on the surface of the earliest mine sites. Only recently has the association of the title with surface rights assumed some significance. Titles to the province's gypsum deposits are now held extensively by the existing operators and, although it would probably be possible to establish other reserves to support a new producer, the process of establishment could be difficult and costly. Not only the gypsum resources but also the timber, gravel, topsoil, and agricultural values would come into consideration.

At the same time, it is clear that the existing operators control more than sufficient reserves to supply their foreseeable demands and, as shown later, the probability is low that an entirely new producer will decide to establish a new production and marketing capability based on Nova Scotia gypsum. Put differently, the history of Nova Scotia's gypsum industry is one of producing to supply available markets and its future

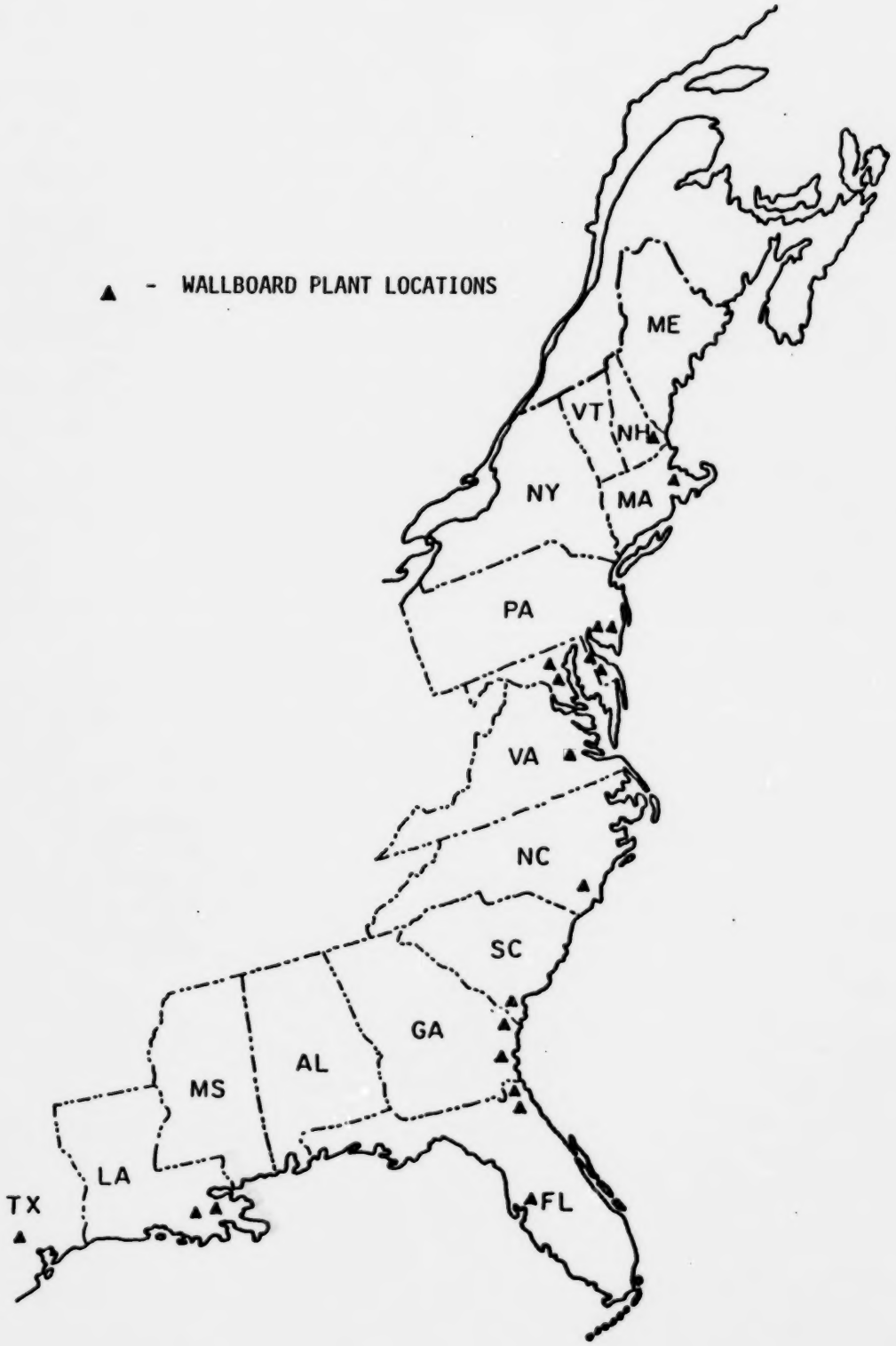

FIGURE I - 1 - 2 LOCATION OF WALLBOARD PLANTS IN OR NEAR ATLANTIC/GULF OF MEXICO PORTS (7).

will be tied tightly to the transportation and market aspects of the industry; the capacity to produce raw material has not been and will not be the critical interest. As a result, this report is aimed more toward the problems affecting, and the opportunities available to, Nova Scotia gypsum than toward the operation of the existing industry.

Section I-2 Purpose of the Report

This report will examine the current status and future prospects of the gypsum industry in Nova Scotia. It became apparent that particular attention should be given to available opportunities for local secondary processing of Nova Scotia gypsum and the feasibility of wallboard manufacturing for U.S. and Canadian markets.

Although the continuity of gypsum production and export from Nova Scotia has not been challenged, the role of the province's industry has been very much that of a raw material producer, quite isolated from the construction industry of the U.S.A. which uses its product. In addition, to an observer in Nova Scotia, the ease of transport of wallboard and its extensive local use frequently have prompted the question 'Why not produce wallboard here in Nova Scotia?'. This is a natural reaction to an apparent opportunity, given the attractiveness of the prospect: jobs in Nova Scotia, use of Nova Scotia fuels and paper, use of Nova Scotia shipping, and so on.

On the other hand, the case for producing wallboard in Nova Scotia has been examined almost regularly over recent decades. Sometimes the impetus has been the argument that the Canadian Maritime Provinces themselves represent a sufficient market for a local wallboard producer. The continuing operation of a wallboard plant in Cornerbrook, Newfoundland, rather than limiting the attractiveness of a Nova Scotia product, tends to confirm the desirability of a local plant.

The main reason why the case for Nova Scotia wallboard must be re-examined is the major change in ocean shipment achieved by the introduction of container freight. In essence, 20 to 40 ton containers are moved internationally by rail, truck, and sea with the facility associated with overland truck or rail but at rates consistent with ocean transport. This represents a major apparent opportunity for wallboard shipment. The use of Halifax as a container port only serves to enhance the appearance of opportunity.

This analysis has not been restricted to the transportation issue; instead, an attempt has been made to seek out any aspect of the industry that might play a significant role in Nova Scotia, and especially to provide an understanding of those aspects of the industry to which Nova Scotia might be sensitive. Initially, this was expected to include the container shipping, mining costs and paper supply but as the examination progressed other features appeared dominant.

In particular, a conclusion from an earlier report[8] was accepted as a starting point for this study: the Nova Scotia market alone is not large enough to justify a local wallboard plant; either or both of the European and U.S. wallboard markets would determine the Nova Scotia potential. Special attention was paid to the European market where timber frame construction is reportedly making inroads into traditional masonry construction. However, the primary concern was not merely the size of these markets, but rather the structure of the industry by which these markets are and might be served.

In planning this investigation, several relevant but non-essential areas of interest have been eliminated, for various reasons. No attempt to evaluate or prove the available gypsum reserves is included; it seems

clear that the adequacy of reserves is not in question though their locations are of critical interest.(9) No evaluation of capital availability is included; it has been assumed that funding would be made available for an attractive industry. It has been assumed that the basic principles of the wallboard manufacturing processes involved should be appreciated, but not at the level of technical detail required for actual operation of wallboard plants.

Since international marketing was inherent in the proposed venture, the investigation includes consideration of international trade issues such as tariffs, import quotas, tax barriers, employment opportunities, including peripheral activities associated with container shipping.

Products of gypsum other than wallboard have not been emphasized in this report although they do exist and may be developed to the advantage of the province. Only broad identification has been attempted for gypsum products other than wallboard, since the establishment of the transportation and market systems is more significant than the products themselves.

Section I-3 Structure of the Gypsum Wallboard Industry

Secondary processing of gypsum in North America is dominated by a relatively small number of large, vertically integrated manufacturers. Approximately 70 percent of the gypsum consumed in the United States is used in the production of wallboard as sheathing or some other prefabricated product. The remaining amount is used in the manufacture of joint filler compounds (either dry or ready mixed) and other basic gypsum products which are used as soil conditioners or as cement set retarders (10). The

first reported production of gypsum wallboard occurred in the United States in 1918. This new product had a major impact on the construction industry and by 1929 annual production had passed 100 million square meters (one billion square feet).

There are five companies currently manufacturing gypsum wallboard and related sheathing products in Canada. These firms and the location of production facilities are shown in table I-3-A. Because of the relatively high mass to value ratio of gypsum products, production facilities are necessarily geographically dispersed in order to minimize transportation cost. There is also a number of smaller and similarly geographically dispersed manufacturers of joint filler compounds and other gypsum products.

Two of the five gypsum wallboard manufacturers shown in Table I-3-A are foreign-owned. Canadian Gypsum Company Limited is a subsidiary of United States Gypsum Company, and Westroc Industries Ltd. is a subsidiary of British Plaster Board Limited.

In the United States, fourteen companies currently produce wallboard in approximately 70 facilities. Five of these manufacturers (listed in Table I-3-A) produce 85% of the total output in 58 facilities.

The industry appears to be highly competitive and because there is little product differentiation, most competition takes place on the basis of price and product availability. While the health of the gypsum industry has traditionally depended on new construction, the recent market for renovations and specialized types of wallboard have decreased this dependence somewhat.

The wallboard manufacturers distribute much of their product themselves, selling directly to large building contractors, construction material chain stores and purchasing alliances. All companies also deal

Table I-3-A

GYPSUM WALLBOARD PRODUCTION FACILITIES IN CANADA

Company	Wallboard Facility Location
Atlantic Gypsum Limited	Cornerbrook, Newfoundland
Canadian Gypsum Company Limited	Montreal, Quebec Hagersville, Ontario
Domtar Inc. (Gypsum Division)	Caledonia, Ontario Winnipeg, Manitoba Calgary, Alberta Vancouver, British Columbia Saskatoon, Saskatchewan Edmonton, Alberta
Genstar Gypsum Limited	Vancouver, British Columbia
Westroc Industries Limited	St. Catherine D'Alexandrie, P.Q. Mississauga, Ontario Winnipeg, Manitoba Calgary, Alberta Vancouver, British Columbia

LARGEST U.S. MANUFACTURERS OF GYPSUM WALLBOARD

Company	Number of Facilities
U.S. Gypsum Company	22
National Gypsum Company	18
Georgia-Pacific Corporation	9
Genstar Building Materials Company	5
Celotex Corporation	4

with building material wholesalers, although this does not appear to represent a majority of their business.

From the standpoint of the feasibility of operating a wallboard plant in Nova Scotia, the integrated nature of the industry is most important. It is clear that any production facility must have a source of raw gypsum, access to paper, and an established distribution and sales network. Consequently, the cost of establishing a production facility cannot be estimated independent of the costs of establishing sources of raw materials and sales and distribution systems.

Section I-4 Commodity Review Methodology

The initial goal of this project was the determination of ways and means by which wallboard production could be established in Nova Scotia. It was expected that a major outlet for that production would exist in Europe where successful promotion of wood products and timber frame construction methods were believed to be establishing a growing demand for wallboard. In that context, the project aimed at establishing the technology and costs of the industry, the competitive raw materials and sources and, especially, the growth characteristics of the European market. Thus, a focus on the European market and the production technology of the industry were expected to be the primary effort.

However, upon establishing a familiarity with the industry in order to develop suitable market analyses, it soon became clear that the industry is integrated vertically to a major extent and that this integration, not possible market features, must dominate the project. In particular,

it was clear that final distribution and marketing aspects of the industry are more significant than either raw material or production systems. On that basis, the case for a Nova Scotia entry into the European market was totally different from that which had been expected; the case became one of determining whether an existing producer might locate a wallboard plant in Nova Scotia for any reason, including the possibility of marketing in Europe. For that purpose, two more or less technical aspects required fairly detailed consideration:

- sources of gypsum in the North Atlantic area that could be considered competitive with Nova Scotia rock or wallboard had to be identified, and
- sensitive cost elements, including transportation, that could bear on or establish a Nova Scotia opportunity had to be developed.

The case for detailed market analyses disappeared because the prospect for establishing a new marketing system was obviously not realistic. Instead, a reasonable overview of the European and U.S. markets was required.

In short, process and system interpretation replaced data collection and reviews as the primary methodology of the report.

The results of the investigation are presented more or less as planned, to facilitate their use in policy development in government offices, in technical and project analyses in the industry and, especially, in the understanding of the industry and its problems by the public.

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Chapter II RESOURCES

Section II-1 Deposit Requirements

(a) Mineralogy:

Gypsum is a rock consisting of the common mineral, hydrated calcium sulphate, ($CaSO_4.2H_2O$), which is very soft, (hardness about 2 on the Mohs scale) and light (specific gravity about 2.3). In its crystalline form this pure mineral is known as selenite and is harder than gypsum rock. A fine-grained, marble-like gypsum is known as alabaster; like marble, it is used in decorative carving. Common terminology applies the name gyspum to both the pure mineral and to the rock although, obviously, a distinction may be significant.

Gypsum is one of the rocks (minerals) known as evaporites that formed by deposition from sea water. As a result, the rock commonly contains other minerals that can also be deposited from such sources, most of which can materially affect the value of the gyspum. These commonly include the anhydrous calcium sulphate, anhydrite, ($CaSO_4$), and calcium and magnesium carbonates, limestone, ($CaCO_3$), and dolomite, ($[Ca, Mg]CO_3$). In addition, the soluble chlorides of sodium, potassium, and magnesium may also be present. Though all of these minerals in the pure state are colorless or white, depending for the most part on their grain size, clays, silt, and other compounds may also occur in the rock to give it distinct colour.

(b) Ore quality requirements:

In principle, gypsum can be used to manufacture wallboard provided it contains enough of the dihydrate to provide a castable product. However, ASTM specifications applying to the strength of the board as well as production considerations make it preferable to use rock of high purity and consistent composition. Current ASTM specifications (1) require that the rock contain more than 70% $CaSO_4.2H_2O$, but most current practice has rock grades of over 80% and rocks containing 92-93% of gypsum are common. At the same time, at least one major wallboard plant is using rock that is close to the minimum quality specification.

Two classes of contaminants can be identified in gypsum rocks: one consists of essentially inert materials in the rock, the other consists of materials that affect the manufacturing process. In the first group are anhydrite, dolomite, limestone, clay and the like which may color the rock or affect its strength; the other group includes chlorides and soluble materials that can react chemically during wallboard formation, or later, thereby adding to production costs or affecting the quality of the product.

The value of a rock is determined by its grade expressed as percent of gypsum, and in terms of other contaminants that may or may not be removable. As a result, a rock is not categorically acceptable or unacceptable; the value must reflect the need or benefits that may be associated with blending it into a plant feed, the costs of additives required to produce an acceptable wallboard and the cost of delivering the rock to the wallboard plant.

Unnecessary contaminants must be kept out of a crushed rock wherever possible. Therefore, overburden, such as glacial till, soil, sand, or plant debris, must be removed from the surface of the deposit before gypsum is mined. The removal process, or stripping, is not difficult technically but it represents a production cost at the mine and affects the competitive value of the mine product. It is noteworthy that more than minimum stripping is required at some Nova Scotia mines, thus diminishing their competitive potential, relative to Spanish deposits where stripping requirements are reportedly minimal.(2)

(c) Structural Features:

It is axiomatic in the mining industry that, the smaller and more complex a deposit is, the more expensive it is to mine. For a high-bulk, low-value commodity such as gypsum, only those deposits that can be mined inexpensively will be worked. It follows that few, if any, complex gypsum deposits are worked.

The structural elements of interest in commercial gypsum deposits are primarily those relating to accessibility, scale, boundaries, and stability. Accessibility relates primarily to the depth of overburden for an open pit operation, or the depth of the deposit if underground mining is considered. Scale refers to the extent of the deposit either vertically or horizontally or both as these determine the gross tonnage available for mining. The boundaries relate to both the structural definition of the mineable rock and, for underground mines, to the stability of the opening left after mining.

For gypsum operations overburden is rarely beneficial. In principle, top soil or gravel, if present, may be saleable but contemporary environmental regulations may require restoration or contouring of mined areas so that the availability of such burden for market is not automatic even if a market exists. More commonly, burden adds to the mining cost because it must be moved to permit mining to begin, and probably handled again to permit restoration of the mining area. On that basis, the less cover the better.

For underground operations, establishment of an access route would involve either a ramp or a shaft depending on depth of deposit, rock types, burden material and so on. The major feature is the depth of the deposit because, regardless of the access method, the access cost increases rapidly with depth. The effect is inevitable; underground gypsum mines must be shallow operations to be commercial.

As evaporites, it is clear that gypsum deposits were formed initially as horizontal bodies or strata with thicknesses ranging from thin to deep layers. For the latter, the horizontal extent of the deposit is clearly less significant than for the stratiform deposits of barely mineable thickness. In either case, commercial deposits are unlikely to have been extensively disturbed by post-deposition geological processes. Surface deposits are generally thick enough to permit low cost surface mining; underground mines are established in extensive, nearly-horizontal strata where low-cost room and pillar mining can be practical.

In underground mines the stability of the rock overlying the deposit is of vital concern as it affects the maintenance of safe working conditions, the dilution of gypsum by overlying rocks, and the fraction of the rock that is recoverable.

In brief, gypsum deposits are commercially useful only when they can be mined by inexpensive methods. In general, the higher cost of underground mining is acceptable only when the delivery cost of raw material from a more distant source is prohibitive. That situation accounts for the underground mining by which wallboard plants in southwest Ontario are supplied.

Section II-2 Conventional Sources

The widespread availability of gypsum in the world has been well documented, along with data on the sizes of many mines and the location and capacities of numerous producing plants.(3) Latest data show Canadian reserves at 500,000,000 tons, U.S. reserves at 800,000,000 tons and world reserves as 2,600,000,000 tons.(4) However, this wide-spread supply also means that gypsum is a low-value commodity and its transport over great distances past closer deposits has rarely been justified. As a result it has not been necessary to compare gypsum from Nova Scotia with gypsum from all world sources. Instead, only those sources that would normally be in the North Atlantic trade need be considered.

As in the cases of most individual large-bulk minerals, such as limestone, there is a scarcity of published descriptions of individual deposit features for gypsum, including geological structures and grades. Lacking such data, the identification of sources that could be competitive with Nova Scotia rock has been based not just on the limited data available but on the practical restrictions that must apply to any source. These restrictions are as follows:

1. The deposit must be located within ten to twenty miles of a deep-water port.
2. Preferably the deposit must have established rail service between the mine(s) and the port.
3. The deposit property must have the characteristics necessary to permit development by open-pit mining methods.
4. There must be a demand.

The locations that satisfy these requirements are shown on the map in Figure II-1-1, but brief explanations of some sources that are not included are appropriate.

First, no Mexican sources are included because only those on the Baja Peninsula are close to tidewater. (It has been assumed that Panama Canal tolls would preclude supply of this Mexican gypsum to Atlantic markets.) Second, sources in Holland, Germany, or Scandanavia have been ignored because these would be most unlikely to be cost-preferable to Spanish (Mediterranean) or French (Channel) sources. British sources are reported to be too far inland to satisfy the mine-port distance restriction.

Details are scarce on most of the deposits identified in Figure II-1-1 but some features are worth discussion. One is that Spanish rock from the Almeria area is currently being shipped to U.S. ports, probably displacing some Nova Scotia rock; the amount displaced in 1984 was about 500,000 tons. The grade of that rock is in the range 92-93% gypsum. No reports were found of rock from the Barcelona area entering the U.S. market.

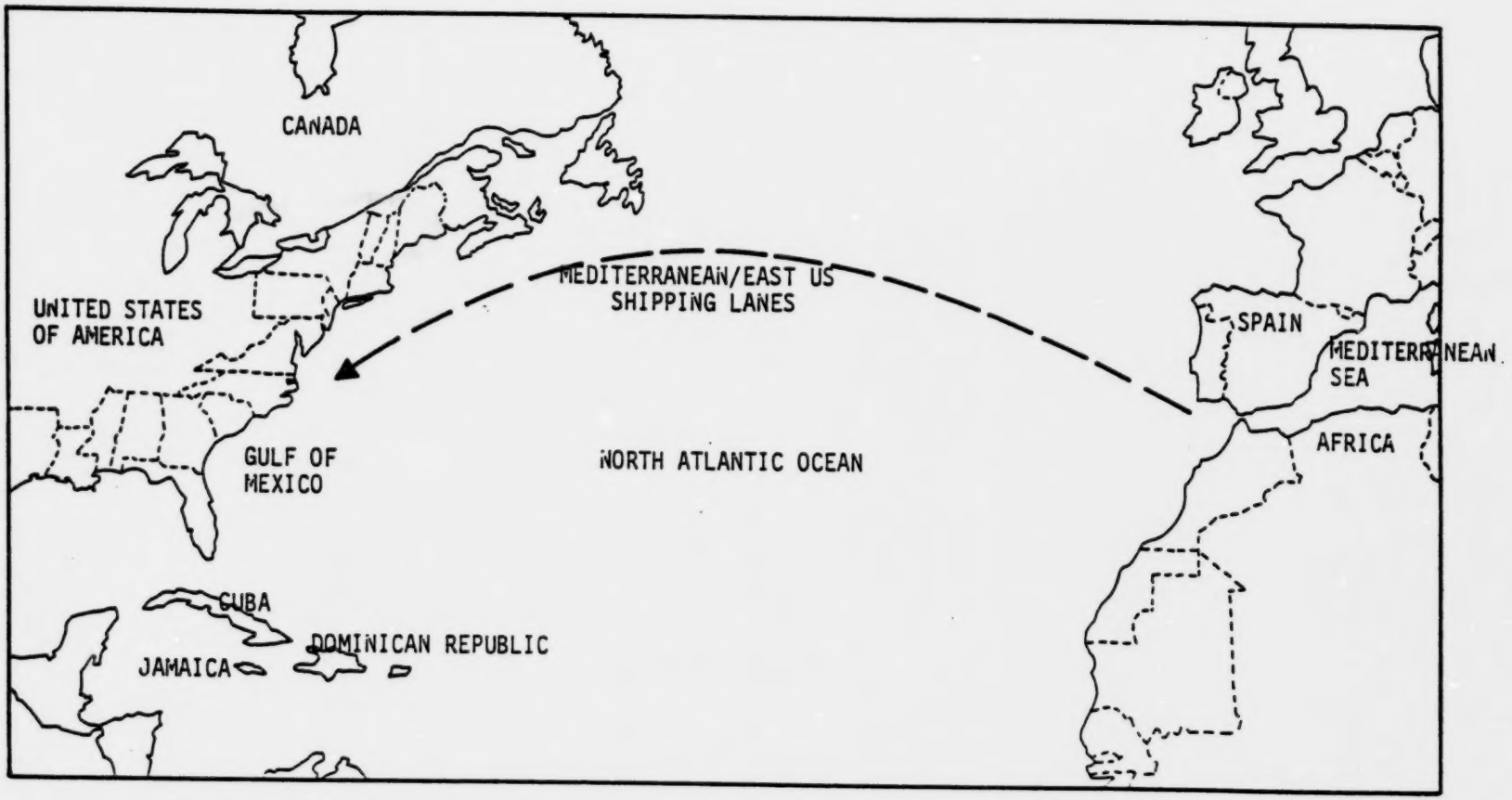

FIGURE II - 1 - 1 - NORTH ATLANTIC GYPSUM SOURCES THAT COULD BE COMPETITIVE WITH NOVA SCOTIA MINES.

Rock from both Jamaica and the Dominican Republic is claimed to be of high grade and sufficiently close to southern U.S. Atlantic ports to be competitive with Nova Scotia material. However, political instability in those areas has weakened American interest in them as reliable sources of raw gypsum. In addition, mining equipment, rail transport, and load-out systems which are available to the Dominican Republic mines, have been inactive for a few years now and are expected to require considerable rehabilitation before those mines could be brought back into production.(5) The Jamaican mines are not served by rail transport at this time but it has been assumed that their proximity to U.S. markets will ensure that they remain a matter of continuing interest.

Though Italy reportedly mines close to four million tons of gypsum per year, no data were available on the marketing of this material. Presumably most of it is used locally. Unconfirmed reports indicated that some material is being exported to the Middle East, and some may be exported as speciality products not identified with the bulk markets. However, shipments from Italy would have no advantage over relative Spanish supplies for the U.S. market. There are two French sources, but they probably do not satisfy the requirements set out earlier. In fact, the Marseille area should not have any advantage over Spanish rock. It is possible, too, that rock shipments through Dunkirk and/or Bologna would be from underground mines. However, some suggestions were made by one mine operator that gypsum has been shipped from these channel ports to Germany or Holland so their presence is recorded here.

In Canada, the only rock that could be competitive with Nova Scotia gypsum would be that from Newfoundland mines now being used to manufacture wallboard in Cornerbrook, Newfoundland. Underground rock from Ontario

could not be considered competitive with the Nova Scotia product in Atlantic coastal markets, and even the Newfoundland supplies can have little if any advantage over Nova Scotia sources.

It is also noteworthy that, though the U.S. is a major consumer of gypsum in wallboard, it does not have sufficient crude gypsum sources on its Atlantic coast to supply the market in that area. Hence the major U.S. presence in the Nova Scotia industry is a natural one. Numerous extensive mid-continent deposits supply inland markets but distances prevent their being competitive with Nova Scotia in the Atlantic states.

Section II-3 Non-Conventional Sources

Gypsum is an anomolous commodity in that it is widely available in both natural and by-product forms. However, while the suitability of natural rock for a specific use is primarily a function of grade, transportation costs, and competitive materials, the utility of by-product gypsum is drastically affected by its production source, preparation costs, contaminants and other factors. As a result, though a by-product may appear attractive at first glance, detailed examination may not confirm that value. This section presents the results of generic reviews of two major by-product gypsums: phosphogypsum (PG), and flue gas desulphurization (FGD) gypsum. Other potential or actual sources are dealt with briefly to complete the picture.

The aim of this section is to identify basic features of by-product gypsum that affect its use in wallboard manufacturing, especially, its technical suitability, cost, and value.

Section III-3(a) Phosphosgypsum

When phosphate rock is treated with sulphuric acid to produce phosphoric acid in the common North American process, phosphogypsum is produced more or less according to the reaction

$$Ca_3(PO_4)_2 + 3\ H_2\ SO_4 + 6H_2O = 2H_3(PO_4) + 3\ Ca\ SO_4 - 2H_2O$$

(310) (294) (216) (516)

with the stoichiometric quantities as shown. The mass of gypsum produced and the magnitude of its disposal requirements can be inferred. The flow-sheet for the process, in somewhat simplified form, is shown in Figure II-3-1 and a typical analysis of a phosphogypsum is given in Table II-3-A. The problems associated with this product as a raw material can be identified in this analysis and in its production system.

Phosphogypsum (PG) clearly contains more than enough gypsum to satisfy commercial requirements; unfortunately it also contains soluble salts and radioactivity.(6) The salts are associated with unseparated acid, as the pH shows, in spite of the multiple washing procedure to which the product is subjected. Apparently the problem is rooted in the fine grain size of the phosphogypsum product which makes thorough liquid-solid separation difficult or impractical by current technology.

The radioactivity in the PG arises from the uranium that occurs naturally in sedimentary phosphate ores and from the sulphuric acid treatment. Uranium is dissolved and extracted in the acid along with phosphates but one of the products of uranium decay, radium 226, remains in the solid

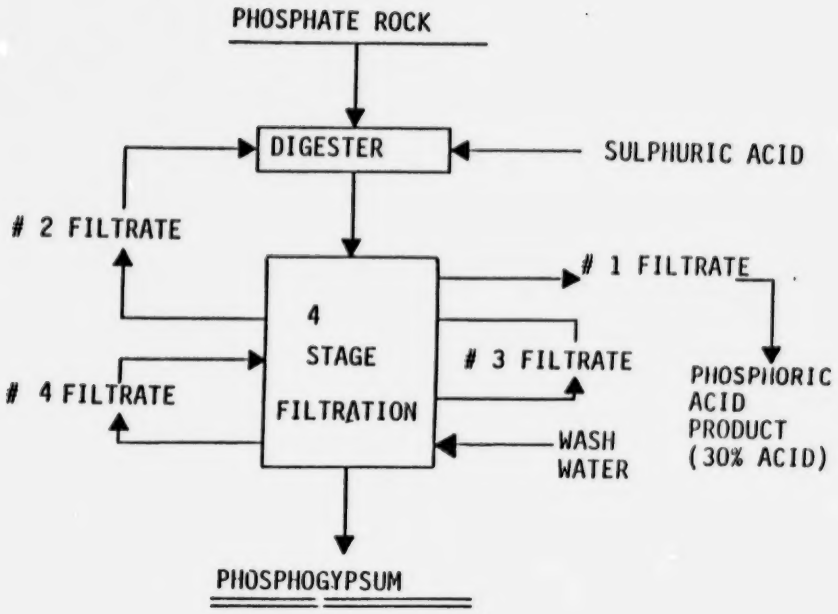

FIGURE II - 3 - 1 - DI-HYDRATE PROCESS FOR PHOSPHORIC ACID/ PHOSPHOGYPSUM PRODUCTION.

Table II-3-A

PHOSPHOGYPSUM TYPICAL ANALYSIS*

Component/ Property	Measure
Gypsum	85 - 93%
P_2O_5	0.2 - 1.7%
F	0.4 - 1.3%
SiO_2	1.4 - 8.4%
Soluble Salts	0.1 - 5.3%
pH	3.1 - 5.3
Radioactivity (R_{226})	15 - 29 Pc/Gm

* All samples from U.S.A. produced material

Source: U.S. Gypsum Research Laboratory

phase as an insoluble sulphate. Although a standard acceptable level of radioactivity may be established for gypsum in wallboard, the level will be lower than that shown in the analysis. In fact, if the level recently suggested as a reasonable target (5 picocurries per gram) is adopted, then extraction of about 80% of the radium 226 will be required to make the product suitable for wallboard.

Nevertheless, it is not only possible to eliminate most of the soluble material from PG, the processes for doing so are being used successfully in Japan and elsewhere.(7) A flowsheet for such treatment is given, again in simplified form, in Figure II-3-2. Basically, the process uses different acid concentrations than in the dihydrate production system to yield an intermediate calcium sulphate which, after acid separation, is subjected to a hydration/recrystallization process. In that last step the grain size of the product is increased to the point where the acid can be washed out and the sulphate is hydrated to the dihydrate state.

In addition, radium can be rejected from the solid in the course of recrystallization and removed by a size separation from recrystalized solids; patents have been issued on such a process.(8)

The difficulty in projecting the use of PG in wallboard lies in forecasting the costs of additional treatment for North American PG and the establishment of an acceptable radioactivity level for PG in wallboard. In any case, the costs of transporting reprocessed PG to wallboard plant locations must restrict its use.

With regard to transport costs, most North American sources of PG are in Florida and, even if the treatment were in place, the cost of shipping the improved PG to out-of-state wallboard plants would approach or exceed the cost of natural ore delivered to the same plants. Most eastern wall-

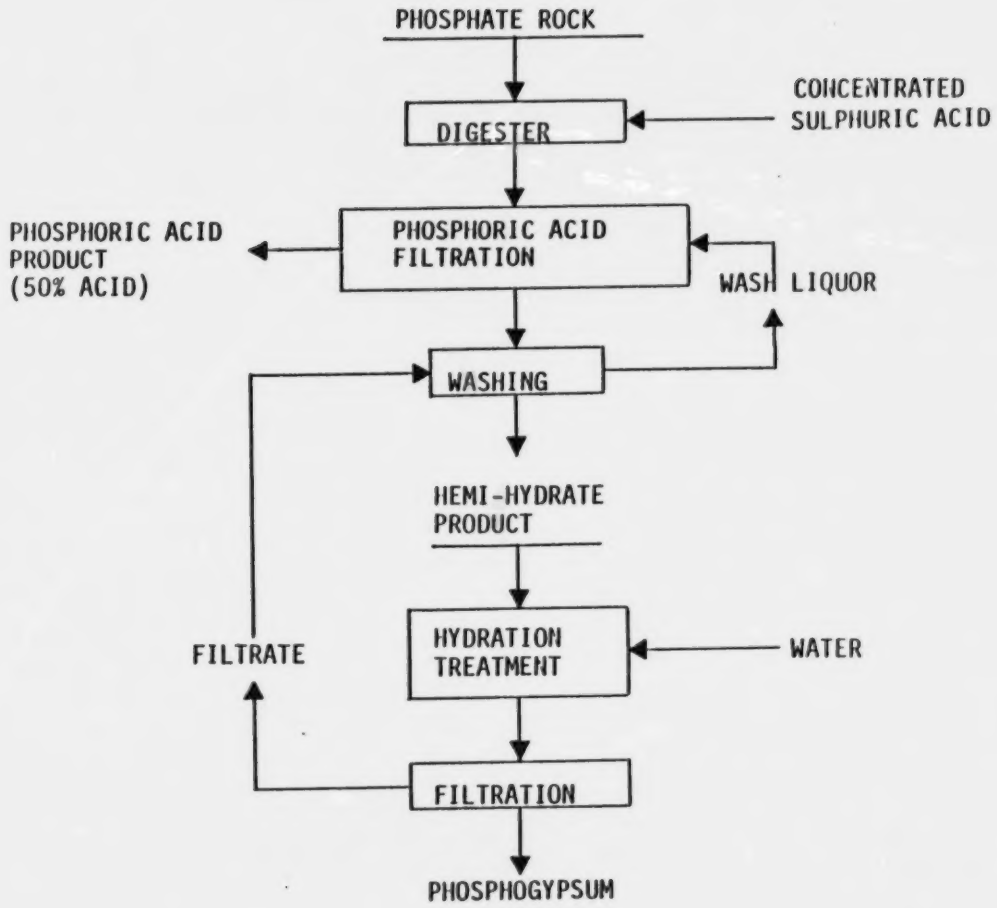

FIGURE II - 3 - 2 - TYPICAL HEMI-DI-HYDRATE PROCESS

board plants are accessible by ocean bulk carriers of rock as the map, Figure I-1-2, shows, so only a few could be considered realistic targets for Florida retreatment operations even if the costs of recrystallization could be assigned to the phosphoric acid production process.

Equally important, pressure to establish a standard for radiation that would permit use of PG in wallboard is unlikely. The problem is limited to Florida operators and eight plants in other states in which phosphate rock is treated (Connecticut, Louisiana, Tennesee, Illinois, Mississippi, California, Idaho, and North Carolina)(3) and the probability is low that agreement will be reached on a standard for what can be classed as an environmentally undesirable and unnecessary hazard. In any event, the acceptable product will be more costly than the existing raw material, and it therefore appears that PG is not likely to become a substitute for natural gypsum in those areas of the U.S.A. in which Nova Scotia gypsum is now used.

Two factors that have not been included above but that could affect this projection should be noted:

1. The development of severe restrictions on landfill or stockpile disposal of PG in Florida.
2. Legislated preparation of PG for use to prevent further development of existing stockpiles.

The first of these does not appear to be a significant risk compared to the cost of retreating a PG, because the cost of accommodating any improved landfill restriction would surely be preferable. The second risk will be more likely to lead to use of PG in low value-added products than

to wallboard markets. Such products and markets might include construction block materials for outdoor applications, and agricultural uses. Even processes that use high sulphur coal and phosphogypsum to produce sulphur may be more attractive than the production of wallboard material.

Section II-3(b) Flue Gas Desulphurization Gypsum

The damage to buildings and vegetation caused by acid rain is, no doubt, the major problem of sulphur dioxide from coal combustion. (That nitrogen compounds may be similar contributors is irrelevant in the present analysis.) Here, the only concern is that the possibility of widespread desulphurization systems may have an impact on the natural gypsum industry, particularly that of Nova Scotia. Therefore, this section focuses on the methods of desulphurization which might be adopted and the products that might be available for disposal or sale.

Processes exist by which sulphur dioxide can be captured from flue gases and made available as sulphur, sulphur-dioxide, sulphuric acid, or gypsum. Moreover, the gypsum product can be provided as one that is suitable for wallboard manufacture, as a disposable wet cake, as a dry disposable product, and, probably in future, as a component in boiler ash. As a result, in evaluating the potential of a flue gas desulphurization (FGD) product for uses in wallboard, the attractiveness of the other products must also be considered.

It is well known, of course, that the sulphur contents of coal vary widely and that the cost of desulphurizing flue gas depends to some extent on the sulphur content of the coal. Ultimately, the value of the product depends on the amount produced. For this evaluation, the likely sulphur

levels of coals can be taken as ranging from about 4% (for washed Illinois coals) to as low as 0.7% (for Western Canada coals).

The chloride content of coals is not well publicized but for coals burned in Eastern U.S. generating stations, it is in the range of 0.05 to 0.2%, commonly around 0.1%.(9) Chlorides generally report to the flue gas from the boiler and accumulate in the liquor used in a wet sulphur dioxide extraction system. To be usable in wallboard, gypsum must not contain significant amounts of chloride. Production of a wallboard gypsum product from most eastern coals will therefore involve both a flue gas desulphurization process and a product washing treatment to remove chlorides.

Flue gas desulphurization systems can be classified as:

- dry, non-regenerative systems
- wet, non-regenerative systems
- wet, regenerative systems
- dry, regenerative systems.

Of these, only the wet non-regenerative ones are potential sources of wallboard gypsum but it is convenient here to consider the systems in the order in which they are listed above.

Dry Non-Regenerative Systems

These are probably the simplest desulphurization systems and are represented in Figure II-3-4. A lime slurry is sprayed into a flue gas stream

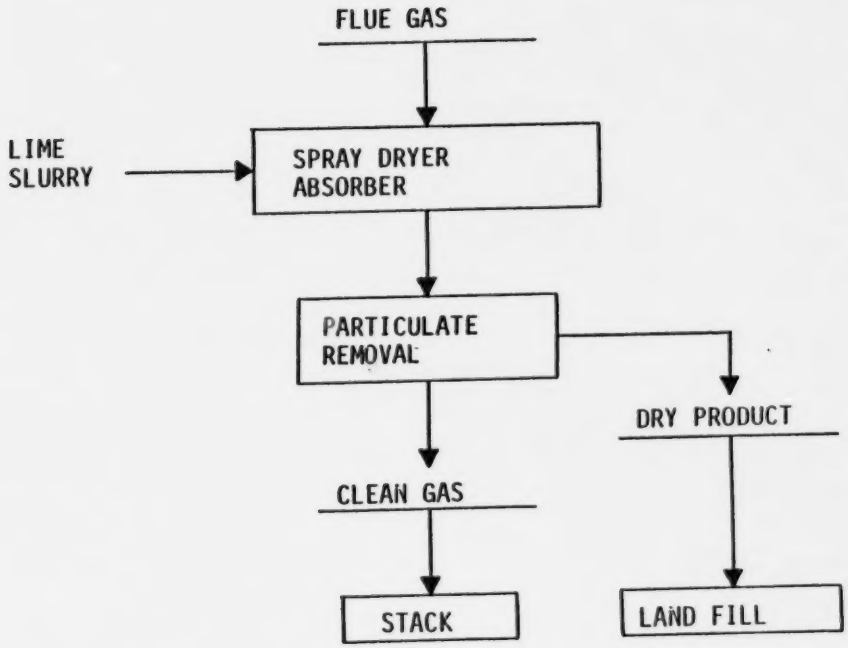

FIGURE II - 3 - 4 - SIMPLIFIED SCHEMATIC FLOWSHEET FOR DRY, NON-REGENERATIVE FLUE GAS DESULPHURIZATION.

from the boiler. The lime reacts with sulphur dioxide and oxygen to form calcium sulphites and sulphates. Simultaneously, the water of the reagent spray is evaporated so that the sulphates, sulphites and dust in the gas can be removed together in the dust collection system. Thus, the sulphur-bearing product is a dry, free-flowing product whose disposal technique is essentially the same as that used for disposal of fly ash.(10) In fact, the dry product probably tends to set up in land fills to prevent leaching and minimize the cost of landfilling.

Dry FGD systems have only been developed commercially in the last six or eight years and experience with them is still limited. However, it is reported that their operating costs are competitive with those of wet, non-regenerative systems while their capital requirements are reportedly about 30% lower and undoubtedly their operation should be simpler. Nevertheless, the cost of lime to combine with sulphur dioxide will be higher than the cost of limestone which can be used in wet non-regenerative systems.

The chloride content of coals is especially significant for dry methods. Chlorides improve the sulphur capture process in the dry method and, if not present in adequate quantities in the coal, may even be added to the capture slurry. Therefore, even if the dust and chemical qualities of the product permitted its use in wallboard, the chloride content may not.

Wet Non-Regenerative Systems

These systems are the most common in current use and so are the ones most often considered in public debate of the acid rain problem.(11) The

process chemistry can be represented by the non-stoichiometric reactions which use either limestone or lime as the adsorber for the sulphur dioxide in line with

$$SO_2 + O_2 + H_2O + Ca\ CO_3 = Ca\ SO_4.2H_2O + CO_2$$

or

$$SO_2 + O_2 + H_2O + Ca(OH)_2 = Ca\ SO_4.2H_2O$$

The process, as shown schematically in Figure II-3-5, incorporates a few noteworthy features that bear on its capacity to produce a product acceptable for wallboard manufacture. In particular, the process provides sufficient retention of slurry in the spray tower reservoir and the thickener to permit enough recrystallization of the gypsum product to make the liquid-solid separation practical. For evaluation purposes, it can also be assumed that the crystallization achieved is sufficient for effective performance of the wash circuit, which incorporates more liquid-solid preparation steps.

Also, in Figure II-3-5, the portion of the flowsheet that is set off by the dashed line is that which is required for preparation of a product suitable for wallboard. It includes a washing step to eliminate chlorides and an agglomeration step to permit dust-free handling and to avoid freezing problems in winter months. The drying step is also necessary because a cake containing more than a few percent of moisture would require drying before it could be fed into the wallboard plant.

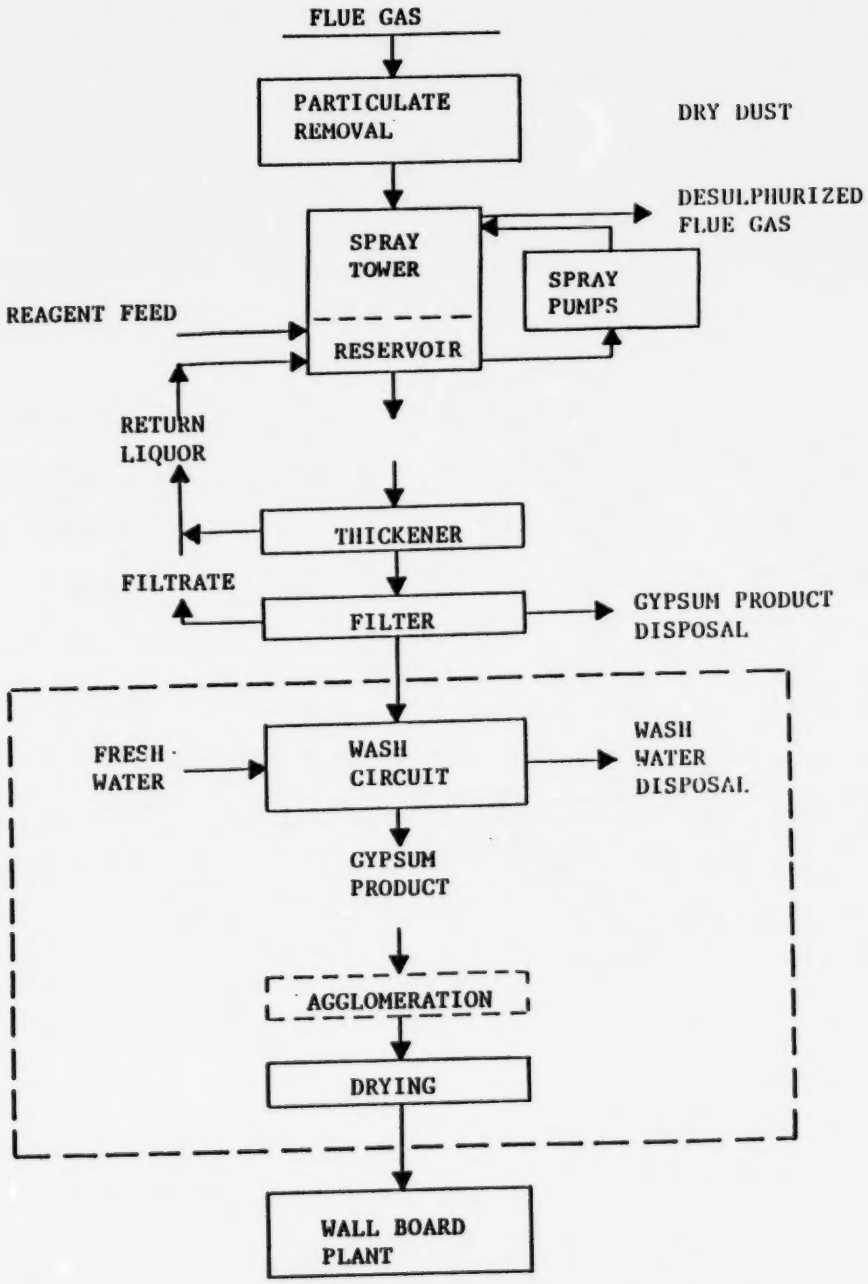

FIGURE II - 3 - 5 - SCHEMATIC FLOWSHEET FOR A FLUE GAS DESULPHURIZATION SYSTEM SUPPLYING A WALLBOARD-QUALITY GYPSUM

The incremental costs of producing a wallboard gypsum from the first gypsum product of the system are estimated in Table II-3-B. The washing cost is projected as the cost of a four-stage washing/filtration treatment which, for a low-density material such as gypsum, will be about two dollars a ton. If only filtration is required the cost will be about one dollar per ton. The agglomeration step assumes use of a bulk plaster of paris or cement mixed with the wet cake and briquetted. For such a treatment, the cost of the binder and the operation are unlikely to be less than five dollars per ton. If drying must be practiced, as seems inevitable even with agglomeration, it is doubtful that its cost will be less than five dollars per ton.

The cost of wash-water disposal is more uncertain than the other items because it will be so dependent on the location of the plant. It may be permissible to dump a fairly dilute chloride waste liquor into a large river; alternatively, if a fairly concentrated brine must be treated to extract chlorides before it is discharged, a significant cost may apply. The allowance of five dollars per ton of product is an intermediate value of published estimates for such treatments[12] and is expected to be a realistic projection for present purposes.

It should be noted at this point that apparently little attention has been given to the problem of brine disposal. If a plant is located on a sizeable fast flowing river so that the brine can be diluted and discharged into the river for further dilution, no problem may exist and the estimated cost of disposal may not be high. On the other hand, a convenient river is not the normal circumstance in eastern United States and even for plants suitably located, dumping of the brine into the ocean may be prohibited. The point is that the estimated cost of brine disposal is not

Table II-3-B

ESTIMATED INCREMENTAL COSTS OF PREPARING WALLBOARD GYPSUM FROM A CRUDE FGD PRODUCT

Item	$/ton
Washing or Filtration	$2 or $1
Agglomeration or Drying	$5 or $5
Wash Water Disposal	$5
Total Estimate with Chloride Extraction	$12
Total Estimate without Chloride Extraction	$6

an arbitrary item; it is introduced as a realistic estimate and carries with it the warning that the problem has been neglected and may be more serious than indicated.

The total projected incremental cost of a wallboard product must also include the transportation charges from the power plant to the wallboard plant. However, if the maximum delivered cost of Nova Scotia gypsum to an east coast U.S. plant is taken as $15 per ton and the haulage cost of $0.20 per ton mile with no backhaul is assumed for moving FGD, the competitive delivery range for a chloride-washed product is only about 15 miles, which suggests a restricted market at best.

If allowances are included for capital costs of equipment and for any part of the FGD system itself, it is clear that the FGD gypsum can only be considered a commercial raw material for a wallboard located nearly adjacent to the generating station.

It is significant that chemical gypsum has not yet been used as a total substitute for natural rock. Presumably, the rehydration behaviour of the chemical product after calcination is variable within wider limits than can be tolerated in contemporary wallboard production. The chemical product is being used to replace only about one third of the natural rock in a system. On the other hand, it must also be assumed that means for controlling this problem will be found, making an analysis on the basis of full replacement appropriate now.

The cost of landfill disposal of the crude gypsum product as shown in Figure II-3-5 may also enter the equation. If losses on wallboard-grade FGD gypsum are less than the cost of disposal of crude product the net cost of making a wallboard product may be an attractive option. On the other hand, the more appropriate comparison given later in this chapter is

between the dry-nonregenerative process and a system yielding a wallboard quality product.

For estimates of the capital and operating cost of a wet-nonregenerative system, the lower values provided by Tearney, Froelich, and Graves have been used.(11) The results are summarized in Table II-3-C for coals of 1%, 2% and 4% sulphur. The capital cost item dominates these charges, but even if only the operating charges are considered, the amount is well above the value of delivered natural rock. Furthermore, these estimates are all based on the minimum forecast charges. If chlorides are present in the coal, washing and preparation will increase the incremental cost. (Table II-3-B)

The conclusion is inescapable: a gypsum product from a flue gas desulphurization system cannot be regarded as commercially competitive with natural rock. If such material is used in wallboard manufacture, it will be because the costs involved have been rationalized. Even then, it is doubtful that any government would knowingly endorse capital expenditures in excess of $3,000,000 per job created to produce a material that will not be cost competitive.

Wet Regenerative Systems

Several systems in this category have been proven commercially and others have been demonstrated at the pilot plant level.(13) For the purposes of the present study, these systems are represented in Figure II-3-6 as consisting of a wet sulphur dioxide capture step followed by a regeneration system. In that format they can be compared with the processes represented in Figure II-3-5 up to the point of gypsum filtration/disposal.

Table II-3-C

PRODUCTION COST OF GYPSUM FOR LANDFILL DISPOSAL FROM A 500 MWe GENERATING STATION

Item	Estimated Cost ($US) for Coals		
	1% Sulphur	2% Sulphur	4% Sulphur
Labour[1]	600,000	600,000	600,000
Power[2]	2,400,000	2,400,000	2,400,000
Reagent	550,000	1,100,000	2,200,000
Capital[3]	7,500,000	7,500,000	7,500,000
Total	11,050,000	11,600,000	12,700,000
Dry Tons/Year of Gypsum Produced	60,000	120,000	240,000
Indicated Cost/Ton of Gypsum	184	97	53
Indicated Operating Cost/Ton of Gypsum	59	34	22

1 Estimated for 20 Persons @ $30,000/year
2 Estimated at 2% of Generated Power @ $0.03/kwh
3 Estimated as 10% of Investment/Year

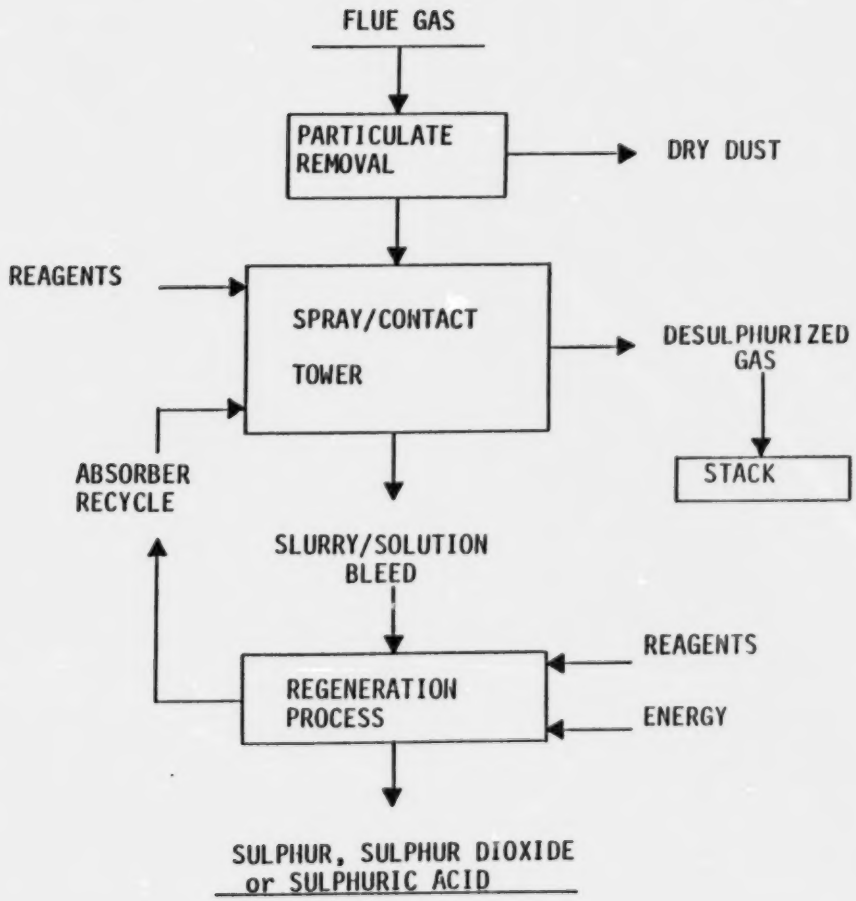

FIGURE II - 3 - 6 - SCHEMATIC FLOWSHEET FOR REGENERATIVE SYSTEMS OF FLUE GAS DESULPHURIZATION.

The first observation on these processes is that the costs through the capture step should parallel those of the same steps in the wet non-regenerative systems. All include spray towers or more costly contact towers, using a slurry or solution of a sulphur dioxide adsorber in water.

Secondly, the investment required for the regeneration step cannot be as low as that of the solid-liquid separation practiced in the non-regenerative process. The actual tonnages of product obtained will be lower when the sulphur is recovered as sulphur, sulphur dioxide, or sulphuric acid than when it is recovered as gypsum. Hence, market values of the different products will not translate into proportionate changes in revenue. This is illustrated in Table II-3-D for gypsum at the approximate cost of delivery of Nova Scotia rock to an average east coast U.S. plant and for the approximate market values of other commodities in the same general area.

The data of Table II-3-D make the regenerative systems appear more attractive than non-regenerative ones until it is pointed out that these indicated revenues are still exceeded by the production costs of even the simple gypsum product as shown in Table II-3-C. The capital costs of the regenerative plants are estimated to range upward from $250 per KWe rather than at the $150 per KWe used to develop Table II-3-C.

Thus the conclusion is inescapable here too: a wet regenerative desulphurization process will not be commercially attractive; its adoption will require major new developments in the systems or major rationalization of the investments required, and perhaps both.

Table II-3-D

ESTIMATED GROSS SALES VALUE $US FOR PRODUCTS FROM FLUE GAS DESULFURIZATION IN A 500 MWe GENERATOR USING COAL OF 2% SULPHUR CONTENT

Product	Product Value $US/ton	Tons Per Year	Indicated Gross Sales
Gypsum	15	120,000	1,800,000
Sulphur	100	22,000	2,200,000
Liquid SO_2	200	44,000	8,800,000
Sulphuric Acid (95%)	60	72,000	4,320,000

Dry Regenerative Systems

These systems have not yet been proven on a commercial scale, and are therefore unlikely to find early use in flue gas desulphurization.(13) Nevertheless, they are included because they have attractive features. In fact the non-regenerative and regenerative systems differ radically and are unlikely to be competitive.

Basically, dry regenerative systems use activated char or copper oxide as adsorbers for sulphur dioxide. The gas is subsequently recovered in relatively costly treatments of the adsorber and presumably can be delivered to market in whatever form is most attractive. Until a very high product value is obtainable for some reason, as yet undefined, dry regenerative systems cannot be forecast for use in flue gas desulphurization.

FGD Gypsum Summary and Overview

If only technical and economic factors were involved, the conclusion that FGD gypsum would not replace natural rock in wallboard manufacture would be clear. FGD gypsum is not cost competitive, and the margin by which it fails is so great that mere process development is not likely to change the pattern.

As for the various FGD processes that may be developed, regenerative technology requires more capital, will be more costly to operate, and is still being developed. Therefore, it is unlikely to displace the wet non-regenerative approach in the near future.

The problem with this simplistic analysis lies in the near certainty that acid rain controls will be dictated politically, and therefore rationalization of the costs is inevitable. One such rationalization is worth considering.

The least expensive method of producing clean discharge from a generating station stack will involve the dry non-regenerative system because that approach reportedly requires about 30% less investment than wet non-regenerative systems. Since the cost of using lime instead of limestone to capture SO_2 will not alter the basic pattern, it is fair to associate 30% of the investment in a wet non-regenerative system with the production of a wallboard product. In addition, filtration, agglomeration, and drying costs will apply if the product must be rid of chlorides. It can be assumed that labour, power, and reagent costs will be similar whether a wallboard gypsum product is produced or not, though undoubtedly power costs will be lower for the dry system. The applicable cost projections are as shown in Table II-3-E.

From Table II-3-E it can be concluded that FGD gypsum will be competitive with natural product only if the wallboard plant is immediately adjacent to a thermal power plant using a high-sulphur coal which contains no chlorides. No practical review could regard this indication of near equivalence as encouraging; on the contrary, the practical conclusion must be that manufacture of a wallboard quality gypsum cannot be justified, it can only be rationalized or tolerated.

It should be noted that, unlike the wet processes, dry FGD systems pose no disposal problems, eliminating political reasons for by-product gypsum production. A dry product can be disposed of with flue dust, which must be captured in any case. In fact, the inclusion of the sulphur pro-

Table II-3-E

ESTIMATED INCREMENTAL COSTS OF PRODUCING WALL BOARD GYPSUM OVER DRY PRODUCT FOR 500 MWe GENERATING STATION

Item	Estimated Costs/Ton Gypsum For Coal Sulphur Levels %/Gypsum Production Tons/Yr		
	1% Sulphur/ 60,000 tons Gypsum Produced	2% Sulphur/ 120,000 tons Gypsum Produced	4% Sulphur/ 240,000 tons Gypsum Produced
Capital[1]	42	21	10
Product Handling[2] without Chloride Removal	6	6	6
Product Handling with Chloride Removal	12	12	12
Total Production Cost Dechloride Wallboard Gypsum with Chloride Removal	54	33	22
Total Production Cost Wallboard Product If No Chloride Removal	48	27	16

1 Representing writeoff of 30% of the investment at 10%/year against gypsum produced.

2 Minimum cost of dewatering gypsum for use in wallboard if no chloride must be removed (See table II-3-B)

ducts, calcium sulphate, and especially calcium sulphite, will probably improve the disposal of the dry product by causing it to set up in time into a firm, clean landfill that is both free of leachates and fully stable.

Section II-3-C Other Chemical Gypsum Products

The production of gypsum from phosphate rock is not at all unique; calcium sulphate is produced in most processes where calcium-containing material is treated with sulphuric acid or when a solution of sulphuric acid is neutralized with lime or limestone. Examples include the production of titanogypsum when producing titanium metal by the sulphate processes, and when producing hydroflouric acid from the mineral flourite, CaF_2. In all cases, the sulphate product is impure, of course, just as phosphogypsum and flue gas desulphurization gypsums are impure as produced, and the sulphate may be anhydrite rather than gypsum depending on the acid concentrations involved. The value of these various products to a wallboard plant depends on the practicality of improving the grade and on the proximity of a wallboard plant.

Currently titanogypsum is being used as a wallboard material in one eastern U.S. plant where it accounts for about 1/3 of the rock required. Nevertheless, the contaminants of an anhydrite product from at least one hydroflouric acid facility will probably prevent its use in wallboard.(14)

In summary, the quality restrictions that have been demonstrated for phosphogypsum and an FGD product with respect to wallboard manufacture are at least as restrictive when applied to other gypsum products. Although

these products exist, each must be evaluated separately. The reasonable first assumption is that they promise little potential as replacements for natural gypsum in wallboard manufacture.

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Chapter III TECHNOLOGY

As might be expected for any product that is sold in large quantities at low prices, the technology involved in gypsum mining and wallboard manufacture is not complex. Since wallboard manufacturing systems operate at high production rates, material and process sensitivities must be appreciated to ensure quality control of the product. For the highly competitive markets to which producers are oriented, the methods and costs of transportation are vital. This chapter aims to identify and evaluate the range of sensitive features that exist in the industry from mining through product transportation.

Section III-1(a) Mining

Most gypsum mines throughout the world produce rock at rates from as low as 200,000 tons per year to as high as about 1-1/2 million tons per year, much of it from open pit operations. These mines are not large in comparison with major copper, uranium and iron mining operations which handle 50,000 to 500,000 tons of rock per day. Instead, they are comparable to the familiar pits and quarries which yield the crushed stone and aggregate used in highway and construction projects.

Gypsum is a soft rock, so drilling and blasting are less intense operations than in other mining ventures. It is even less dense than limestone, so loading and haulage requirements are less demanding. Moreover, gypsum is not subjected to extensive crushing, sizing, or treatment

before shipment, making it unique among natural mineral commodities. For cost and technical analyses it is convenient to examine gypsum mining operations in five steps (as shown in figure III-1-1) which can be used for either surface or underground mining systems.

For surface mines, the access operation consists of stripping or removal of non-gypsum materials from the surface of the deposit. Rarely is this a major operation comparable to stripping of coal seams or tar sands. Instead, gypsum stripping consists of removal by scrapers, dozers, loaders and trucks of gravels, soils, etc. to depths of less than 20 metres. The use of a dragline to remove burden at the River Denys operation of the Georgia Pacific company in Cape Breton Island may represent the extreme of gypsum stripping operations.

For underground gypsum mines, the cost of establishing and maintaining access requires that the deposits be relatively shallow. For example, at Domtar's New Caledonia mine the gypsum strata are less than a hundred feet below surface, and the Drumbo mine is about 400 feet below surface. The choice of access to such deposits, whether by a decline or shaft, depends on local considerations.

For surface mines the rock breaking operation generally parallels the operation in pits and quarries. Diesel or air-powered drills are used to establish blast holes in which conventional, low-powered explosives are loaded. Blasts rarely yield more than about 50,000 tons of rock and because the rock is soft, and explosive costs comparatively low, most operators can be expected to seek maximum fragmentation to facilitate handling of the broken rock.

In underground mines, the large vertical blast hole of the surface operation is replaced by the more or less horizontal small hole. For

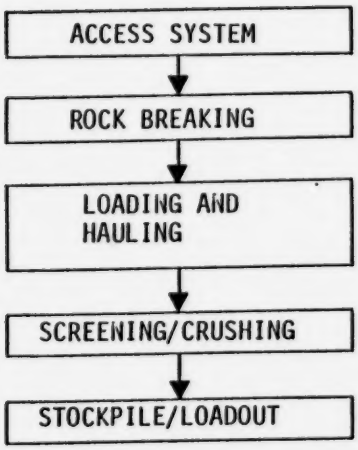


FIGURE III - 1 - 1 - THE STAGES OF GYPSUM MINING

safety, the system must also provide support for the roof of the mine after the rock is removed. These differences mean that underground breaking operations are more costly than for surface mining and that extraction of the deposit is limited. Room and pillar mining with rock bolting to support the open areas, is the conventional practice in Canada.

It is likely that underground gypsum mines will move toward continuous mining using the cutting technology developed in potash mining and in tunnelling. Two benefits will result. One will be better control of rock grade through avoidance of over-breakage into the ceiling and floor; the other will be improved safety.

Loading and haulage in open pits will continue to use conventional trucks and front-end loaders. It is doubtful that in-pit crushers and conveyers will be used in gypsum mines as they are being introduced in open pits and quarries; in general, the scale of gypsum operations is too small to justify the investments that these approaches require and the seasonality of Nova Scotia operations would also tend to limit their value.

Underground rock movement normally involves mechanical loaders and conveyors or conveyors from continuous miners.

Crushing, with or without screening, is required to reduce rock size for bulk carrier transport to wallboard plants. Normally, the limitation is the self-loading equipment on the bulk carrier; a product in the range of six inches is common. Since gypsum rock is not hard, this crushing step is both conventional and low in cost; by mining standards, light duty equipment is applicable.

The stockpile/loadout operation is not likely to exist at most underground mines, which tend to be located at or very close to the wall-

board plant they serve. For an open pit operation whose product is transported by bulk carrier to a distant plant, however, two factors must be recognized. One, obviously, is that the mines must be located at the deposit. The other is that loadout rates must conform to carrier costs not to mine production rates and schedules. Consequently, both land transport and stockpile/loadout facilities are necessary and have significant cost effects on the final products.

Section III-2 Processing

The process of forming wallboard is simple in concept: a slurry of calcined gypsum is allowed to harden between two sheets of paper board which are bound at their edges. The ribbon of wallboard so formed is cut to desired lengths and dried. However, for this process to be carried out at maximum rates while producing board which meets close specifications at minimum cost, a somewhat sophisticated system is required. The purpose of this section is not to dwell on the elements and details of that sophistication but to describe the major features of the process and to identify a few features that lead to the sophistication of the requirements.

A schematic flowsheet for a wallboard plant is shown in Figure III-2-1 beginning with the ore as delivered from the mine and ending with the loading of finished wallboard for shipment to a consumer or retail outlet. It is inherent in this flowsheet that inventory in wallboard plants is usually concentrated in either mine rock or finished wallboard; rarely is there an intermediate product which could permit location of a preparatory (calcining) section in one location and the remainder of the

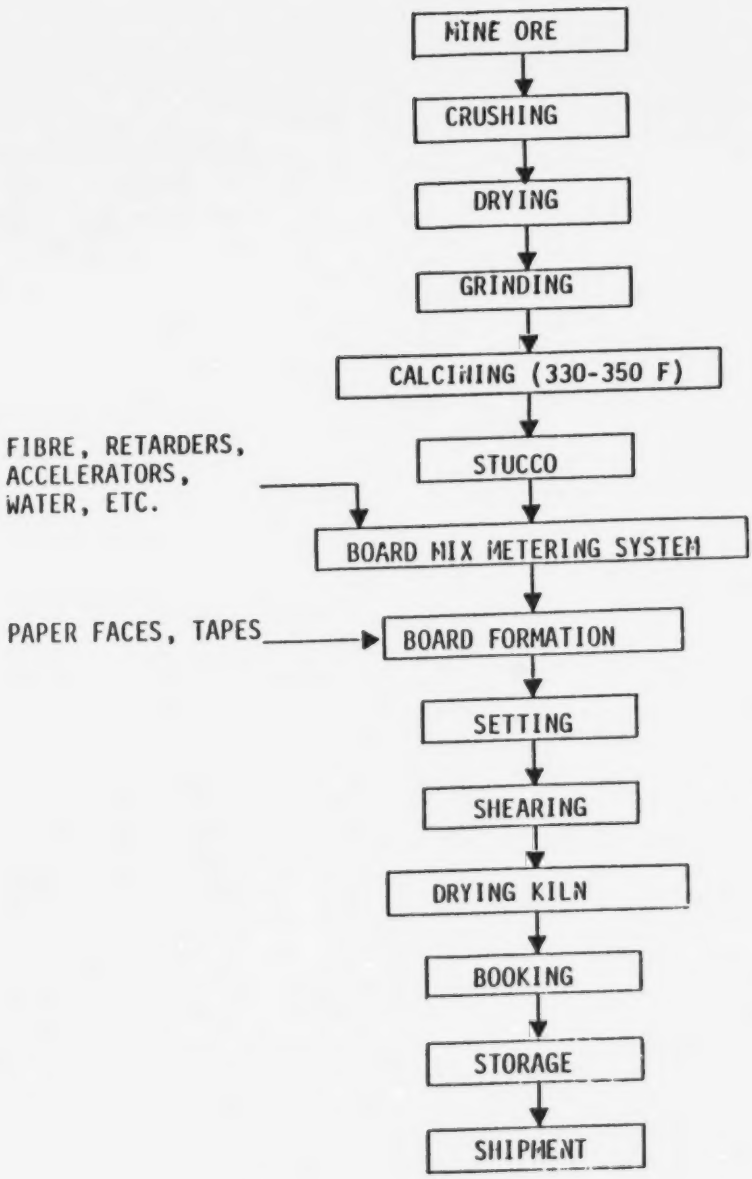


FIGURE III - 2 - 1 - SCHEMATIC FLOWSHEET FOR A WALLBOARD PLANT.

plant in multiple market areas. Calcined rock, known as 'stucco', is not a readily storable or transportable product because of its extreme water sensitivity, so the entire plant is usually constructed under one roof. That means that fairly large, flat-lying areas on tidewater are preferred plant sites.

The first step shown in the flowsheet is crushing of the mine ore, from about six inches to a maximum of about three-quarter inches, often in a hammermill. This large size reduction in a single unit is practical due to the softness of gypsum. If the rock contains undesirable fines that could affect colour, process reaction and so on, it may be necessary to wash and/or screen out such fines before grinding and calcining. In that case, the crushing, screening, washing and drying operations will be integrated so as to minimize water retention and drying. A kiln-type dryer is likely to be used at this stage. However, if a fine-grained feed such as chemical gypsum is to be dried, different equipment may be required both to avoid dust loss and to accommodate the higher water contents that are usually present in such materials; the water content of a filter gypsum cake is likely to be between 15 and 20% whereas coarse rock is unlikely to retain much more than 2% of surface water.

It should be emphasized that it is not practical to combine drying and calcining steps, though both eliminate water from the rock. Even before calcining, excess water can be a problem in some grinding systems by causing caking and hangups in material transfer equipment. More important, the close control of temperature required in calcining necessitates a fairly constant and minimum water content in the calciner feed.

The grinding step reduces the gypsum rock to 90% finer than 100 mesh (a 100 mesh screen has square openings 0.15 millimetres to the side).

Again, due to the softness of gypsum, it is practical to carry this step out in a single machine, generally a roller or impact mill, in conjunction with flash drying for low-moisture rock.

The most common equipment for calcining ground rock has been the kettle, in which batches of pulverized rock are heated for periods of two to three hours to eliminate 75% of the water of hydration from the gypsum. The reaction begins at temperatures as low as 170 degrees F. for some rocks, with the end point dependent on the rock to some extent. In normal practice, calcining is terminated at temperatures in the range of 330 to 350 degrees Fahrenheit because, though stucco taken to higher temperatures will reset, the setting rate is slower. Thus calcination temperature is a critical control item.

Calcination is also carried out in some newer plants in continuous kettles or by flash calcination integrated with impact grinding. These process modifications are possible because fine particles of gypsum need only be at calcination temperature for short periods of time for the required dehydration to take place. The essential elements of the process are the transfer of heat to the system and the control of maximum temperature, not the reaction rate of the rock. Continuous processes are now practical because the means for closely controlling heat transfer have been developed.

It is interesting to note here that the name "kettle" probably reflects the low heat requirements of the calcining step. When powdered gypsum is heated in a batch kettle, the evolution of water is so rapid as to make the powder appear to boil. This is in marked contrast to the reaction rates in metallurgical operations when ores and concentrates are calcined (roasted) at much higher temperatures to remove sulphur or carbonates.

As indicated in Figure III-2-1, the gypsum core of wallboard includes not only stucco and water but a range of additives that establish different qualities in the board as well as controls on the process. For example, paper fibre may be added to provide some tensile strength in the board, fibre glass may be used for the same purpose in manufacturing fireproof board, foam may be added to create voids in the gypsum to lower the unit weight of the product, accelerators may be used to increase the setting rate, retarders may be added to lower the setting rate, and viscosity control reagents may control the flow of the slurry. However, one major factor to consider if additives are used is that more water is required for setting the stucco. The extra water yields a slurry that will flow and form the board sandwich smoothly but that means that the board must be dried after forming to eliminate this excess water. Of course, the forming additives that establish voidage in the board core also facilitate the drying operation.

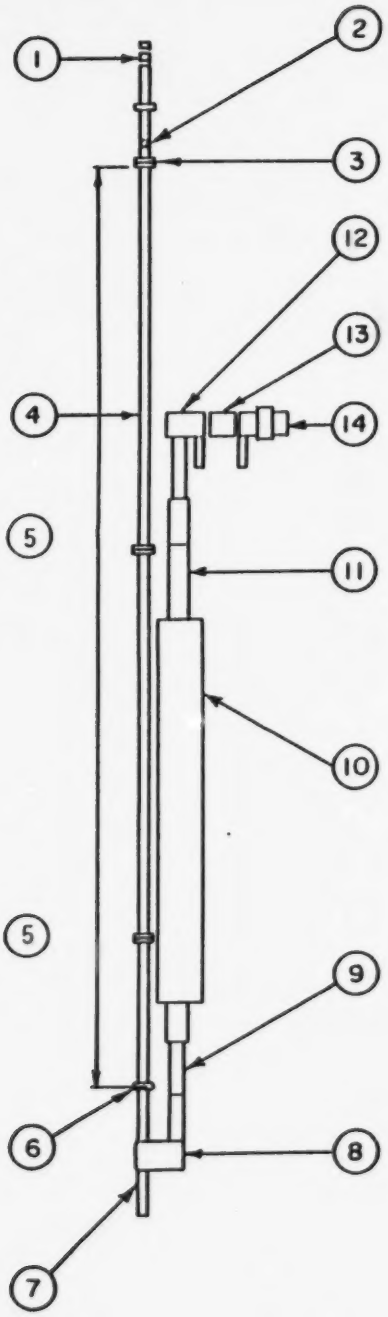
Setting of stucco and formation of a dimensioned board occurs as wet slurry from the forming machine, sandwiched between two paper layers, moves along a continuous moving belt that is long enough for the board to assume its final solid form without being twisted or transferred. The capacity of the machine is set by the rate at which the belt moves and the length of the belt. For contemporary plants, belt speeds are in the range of 200 - 250 feet per minute and setting times may be up to six minutes. Belt lengths in the setting zone are in the range of 1200 to 1500 feet to accommodate the total length of the board machine from the feed rolls for paper to the discharge conveyor for spoiled board sections. A plant building length in the order of 2000 feet is required. A machine operating with a belt speed of 225 feet per minute is rated by one supplier as capable of producing about 340,000,000 square feet of board per year.

When the board has set, it passes a cutoff knife that cuts it into slightly overlong product lengths which are then ready for drying. Cutoff sheets are inverted and transferred normal to the line of the forming machine (see layout shown in Figure III-2-2) so as to follow a return path through a dryer to final dimensioning, booking, taping and storage. Obviously, the direction reversal shortens the length of the building required to house the system.

The major equipment item for the formed board is obviously the dryer. Normally these are gas fired units in which the board is heated to a maximum of about 200 degrees fahrenheit to effect drying. It is critical that the temperatures achieved in the drier not be so high as to calcine the gypsum again. This is avoided by close temperature control of the hot gases in the dryer and the use of sensible heat in the board to complete the drying process. The dryer is the major energy consumer in the plant because of the large amount of water to be driven off the board, so close control and maximum heat recovery are sought.

Since the maximum temperature achieved by the dryer gases is about 600 degrees F. it would be practical to use a coal-fired system or a coal/steam heat transfer system. However, it is also clear that distinct advantages exist for gas-fired systems, with oil as the preferred backup fuel.

In the booking section, pairs of sheets are cut into final lengths, the cut ends are taped to hold the pairs together, and the sheets are stacked for storage and shipping. For half-inch board, which is the most common thickness produced, 15 pairs of sheets are usually piled together to form a single lift 15 inches high and weighing about 1600 pounds. Dunnage between lifts is provided by six 4- to 6-inch wide strips



1. PAPER ROLLS
2. MIXED
3. FORMING MACHINE
4. BELT (SETTING)
5. CROSSOVER WAYS
6. SHEARING (BOARD CUTTING KNIFE)
7. REJECT CONVEYOR
8. TRANSFER - INVERTER
9. DRYER FEED MECHANISM
10. DRYER
11. DRY BOARD CONVEYOR
12. TRANSFER - BOOKER
13. BOARD BUNDLER
14. STACKER

FIGURE III - 2 - 2 - GENERAL LAYOUT OF WALLBOARD PLANT EQUIPMENT

of board cut in the final dimensioning step. Storage area clearances are in the range of 26 feet, sufficient for stacking over 15 lifts. To handle the production rates of contemporary plants and the inventories that are essential to competitive marketing, large storage areas are required.

To satisfy market requirements, plant equipment can be operated to produce different thicknesses and lengths of board as well as different core compositions. Also, stacking arrangements can be set to satisfy product or customer demands. The most common sheet length is 8 feet but 12-foot lengths are also standard, and essentially any length can be produced if the market justifies it. The mix and product data for one plant are illustrated in Table III-2-A.

Section III-3 Paper

The paper used for wallboard manufacture establishes two vital qualities in the product. The most obvious is the smooth finish of the product; the other is tensile strength in the board. This strength, coupled with fibre and voidage in the gypsum core, permits the board to flex without breaking. These qualitites make it practical to nail board to supporting frames and ensure the utility of the mounted board as a stable wall with a finished appearance.

Wallboard paper is manufactured generally from recycled fibre in two layers. The outer layer is commonly formed from clean (unprinted) newspaper clippings to provide a white, fine-grained finish. The thicker, inside layer is formed from a range of fibres that includes sufficient long, coarse fibre (from corrugated scrap) to establish a strong bulky

Table III-2-A

ILLUSTRATIVE OPERATING DATA FOR A PLANT PRODUCING 1/2 INCH BOARD

Material/Item	Quantity per MSF*
Forming Machine Mix	
Stucco	1400 - 1500 Pounds
Water	1050 Pounds
Paper	110 Pounds
Total Product Weight	1600 - 1800 Pounds
Total Energy Required	2,200,000 BTU
Approximate Dry Rock Required	
@ 72% Gypsum	1665 Pounds
@ 90% Gypsum	1700 Pounds

* MSF = 1,000 sq ft.

material that is also porous enough to permit penetration by gypsum slurry in forming. The result is a strong bond between the core slurry and the paper. Board can be made with the same paper on both sides, but this is not common. There is an obvious cost advantage to using an unfinished paper on one side.

The quantity of paper used is about 110 pounds per 1000 square feet of board, meaning that a state-of-the-art wallboard plant producing 340 million square feet of board per year requires about 19,000 tons of paper. However, that quantity is considerably less than the capacity of an economically-sized paper mill. Because wallboard paper is a specialty product that cannot be produced arbitrarily in any particular paper mill, sources are limited.

For instance, the machine of the Minas Basin Pulp and Power Company of Windsor, Nova Scotia produces a sheet only 88 inches wide from which 48 inch-wide wallboard would represent an intolerably low recovery. A machine width in excess of 96 inches is essential for commercial wallboard paper production. Supplying paper stock for a wallboard paper mill would require a considerable collection and delivery system in addition to those already operating in the Maritimes. Furthermore, the supply of recycled paper to any east coast mill is reportedly highly elastic and sensitive to price.(1)

It follows from the foregoing that paper for a wallboard plant in Nova Scotia is not likely to be produced in a Maritime mill. At present, essentially all wallboard paper in eastern Canada is supplied by Beaverwood Fibre Company of Thorold, Ontario. Whether it will continue to be supplied from Ontario, with the associated freight charges, or whether it

would be imported from a U.S. mill as backhaul on wallboard delivery vessels (see section III-4), is likely to depend on the individual board plant owner.

It may be possible that, if one or more Nova Scotia wallboard plant(s) are established, a case will also exist for incorporating a recycling facility using paper collected in U.S. cities and delivered to Nova Scotia as backhaul on the board delivery vessels. In that case, wallboard and other paper products producable in the same mill might be exportable. Therefore Nova Scotia's energy, space and shipping facilities, including container freight, could be utilized to upgrade waste paper for export markets. However, that prospect is outside the present study.

Section III-4 Transportation

In the manufacture of wallboard, three separate transportation systems are commonly involved:

- transport of bulk ore from mine to ocean carrier;
- sea transport of bulk ore from port to wallboard plant;
- transport of finished wallboard to a consumer/distributor, generally by truck (to a distribution centre) but for larger quantities rail service is also used.

It is useful and instructive to examine each of these systems to establish the sensitivity of the overall business to each.

Section III-4 (a) Rail Transport of Bulk Rock

As pointed out earlier, gypsum is usually mined in quantities of over 300,000 tons per year. The production season is commonly in the range of 200 days per year. Therefore, a quarry delivers a minimum of 1500 tons per day, a quantity of rock that requires a regular transport capacity normally available only through a railroad system using unit trains. Undoubtedly, the quantity is too large for truck delivery beyond the mine boundary. For larger mines producing more than 1,000,000 tons per year, the only variation in the unit train delivery to ports is in the size and number of trains in use. Locomotives and crews for unit trains in gypsum haulage are not likely to be dedicated to the service because much less than full capacity is utilized.

A second noteworthy feature in the transport to a port is that even for a large mine, daily production is not sufficient to load a bulk ocean carrier of the capacity normally used, nominally over 15,000 DWT and more commonly in the 20,000 to 30,000 DWT range. The effect is that port facilities must include car dumping equipment, stockpiles and stockpile recovery equipment in addition to a loadout conveyer. As a general rule, loadout facilities deliver rock to the vessel at rates above 1,000 tons per hour. An exception is the loadout facility at Hantsport on the Bay of Fundy where extreme tides limit loading periods to less than three hours and require much higher loading rates.

In Nova Scotia, rail transport operations use CN lines between Georgia-Pacific operations on Cape Breton Island and loading facilities at Port Hawkesbury. National Gypsum also uses CN lines between their Milford quarries and loadout facilities near Dartmouth on the Bedford Basin. The

Fundy Gypsum Company uses a CP line between their quarry near Windsor and loadout facilities at Hantsport, while no rail haulage is required at the Little Narrows operations.

These rail operations are different from those of conventional unit trains because of the short distances involved. Whereas coal operations from Alberta and various British Columbia mines involve transport over several hundreds of miles, the Nova Scotia operations are limited to about 40 miles for National Gypsum, about 18 miles for the Georgia-Pacific service, and less than 10 miles for Fundy Gypsum. Inevitably, the small tonnages and short distances involved amount to special services from a rail viewpoint, and unit rail costs must be higher than for the long distance hauls of western Canada.

Section III-4 (b) Ocean Transport of Bulk Ore

The cost of ocean transport of crude gypsum has been considered a small cost item in the wallboard industry, has been a factor in the development of the Nova Scotia gypsum mining industry, and as well, has contributed to arguments against a wallboard plant in Nova Scotia. Given traditional methods of transportation, it is much more costly to transport finished wallboard than bulk rock. However, current patterns of bulk carrier trade are having a significant effect on the industry and even greater effects may develop for Nova Scotia operations. Therefore it is appropriate to examine the bulk carrier business in some detail.

First, it is useful to outline briefly the features of ocean bulk carriers which are relevant to the gypsum industry, particularly the size of the vessels and their unloading capabilities.

It is important that a gypsum carrier be a self-unloading unit because the rock is delivered to a plant stockpile which, almost by definition, will be a private dock or pier. For the volume of rock to be handled, the use of dockside cranes to unload is slow by comparison to the unloading rate of a self-unloading vessel. Because a wallboard company will have several receiving ports to which gypsum must be delivered, it is less costly to establish unloading capability on a vessel than to establish unloading facilities at every port.

Unloading equipment on a carrier can take several forms. At one extreme, holds can be designed as bins with drop points below to feed conveyors which deliver the rock to a bucket elevator. The elevator can then raise the rock to deck level at which point it can flow via a boom conveyor to a shore handling system. Alternatively, the vessel may have scraping mechanisms in the holds that pull rock to a central discharge port from which it moves on conveyors to a dock delivery system. The need for the sloping slides of bin-type holds is eliminated in favour of a greater usable hold volume. Whichever method is used, unloading can be achieved with rates in the thousand of tons per hour range.

The size of the vessel is also significant. Most gypsum rock currently is delivered in vessels of less than 35,000 DWT because company terminals to which gypsum is delivered on the east coast of the U.S.A. will not all accommodate large carriers.

It is also normal for gypsum rock to be carried in vessels which are owned or chartered by the wallboard company, at least to the extent required to guarantee rock delivery. Before oil prices began to dominate shipping costs, wallboard companies often used their own carriers; it was quite practical to operate a vessel dedicated to gypsum haulage. Hauling

rock from a company terminal in Nova Scotia to a company pier in the U.S.A., with no other trade involved, permitted registration of vessels under flags of convenience. That arrangement insured minimum cost for transport without the risks of the cost increases potentially applicable when relying on contract haulages.

Over the last few years however, the pattern of bulk haulages in the North Atlantic has altered considerably. Currently iron ore, coal, bauxite, phosphate rock, potash, and a variety of grains are hauled out of Carribean and Gulf of Mexico ports to European terminals but few, if any, return bulk cargos are available. In addition, the quantities of some of these commodities moving to Europe have diminished as aluminum smelting elsewhere has reduced bauxite shipments, as the Europeon steel industry has shrunk, as African phosphate has become available, and so on. In total, more bulk carriers are available than required(2) so competitive costs have become the rule and westbound movement in ballast is obviously undesirable.

One effect has been the growing pattern, noted earlier, of carriers bringing gypsum from Europe, especially Spain, to east U.S. ports. In fact, some deliveries have been made to west coast U.S. ports. The practice is reasonable because the incremental costs of such deliveries to a vessel moving westward in ballast are little more than the time costs of diverting to port, loading, and unloading; the fuel consumption differential in ballast versus loaded is not significant.

The pattern for Nova Scotia seems clearly to indicate a gradual replacement of Nova Scotia shipments with Spanish rock. Alternatively, haulage of Nova Scotia rock as a backhaul commodity may reduce the use of dedicated vessels. In either case, the balance may depend on the manufac-

turer's decision with regard to continuance of vessel or fleet operations, guarantees of delivery, and increases in plant-site inventory.

Section III-4 (c) Wallboard Transport

As outlined earlier, wallboard is stacked in convenient lifts of about 30 sheets of half-inch wallboard or equivalent for handling and shipment. Shipment is commonly by truck with 20 to 30 tons being the normal load. Rail shipment is by boxcar.

One attractive feature of truck shipment is the fact that board can be delivered directly to a job site without extra handling, and storage on-site can be minimal. For most projects, weather shelter exists by the time wallboard is required so that shipment from the plant to the construction site requires no wrapping; loads covered with tarpaulins are suitably protected from rain. The same situation with regard to weather exists for shipments to retail outlets. Since most such outlets are equipped with fork lifts or cranes anyway, no special handling facilities are required there either.

The ease of truck transport tends to limit the competitive range of a plant. The distance from a plant for which supply is competitive is determined to a large extent by the trucking capability of the area, including the opportunity for backhauls, number of trucks, state of roads and so on. As a first approximation, truck delivery of wallboard is likely within a range of 200 to 300 miles from a plant. For more distant deliveries, rail shipment of larger quantities with or without satellite distribution is likely.

For box car loads, weather protection is not necessary but board length may be restricted by the car width, which is commonly 9 feet 2 inches or less.

For both truck and rail shipments, wallboard must be restrained for safety reasons and to prevent load damage. The construction industry prefers that wallboard sheets slide on each other readily so high speed highway transport and the humping and jerk-starting of trains can cause damage or potentially dangerous load shifts. For road travel, some provinces have strict regulations on load ties; for rail purposes, either dunnage or firm bracing is necessary.

Wallboard can be transported by sea as deck cargo with or without weather wrapping or it can be stowed. For loading and unloading, the material may be palletized or moved with slings. In any case, the issues of interest are those of handling costs and damage. It is likely that reported deliveries of wallboard from Europe to east U.S. ports reflect temporary shortfalls of local supply or other market aberrations rather than a new pattern that is likely to last.

On first glace, the prospect for shipping wallboard in containers is attractive in the sense that the usual objections to ocean transport of the product, including handling and weather damage, would be avoided and presumably bulk shipping rates would be achieved. However, closer examination proves this incorrect.

The first major shortfall of container shipments concerns the feasibility of loading containers. The outside width of containers is standardized to facilitate handling and the inside width is commonly 7 feet 8 inches, not suitable for 8' sheets or adaptable for use with a product having 4' dimension multiples. Use of containers would require use of

special loading and unloading rigs and considerable dunnage as well; gross underloading of the containers is inevitable.

A second major drawback to containers is the requirement that they be loaded and unloaded from container ships at container terminals, not at a port of choice. A wallboard plant is quite unlikely to be located at or even near an existing container terminal because of the large area requirement of the plant and the high value of active terminal property. As a result, use of containers will impose a truck or rail transport stage at both ends of the voyage.

Third, given the current structure of the industry, the basic requirement of ocean transport of wallboard is that the shipment cost must approximate the cost of transport of bulk rock. In fact, container transport rates are not competitive with bulk transport rates within the ranges of interest in this study, even disregarding the above technical objections. Container freight charges can be expected to be about 3 times the cost of the bulk freight charge even without considering the cost of delivering containers to and from terminals.

Containers are, in general, an excellent shipping method for high value products or in special circumstances. In such cases, containers establish security and reliable delivery schedules at what may be acceptable cost. However, these features have little or no value when applied to wallboard because the cost of wallboard transport must be competitive with bulk rock shipment.

This analysis of ocean shipping methods does point to an as yet unused but apparently practical means of shipping wallboard that may indeed be competitive with bulk shipments for rock. To describe this new prospect, one can assume that a wallboard manufacturer has a wallboard plant

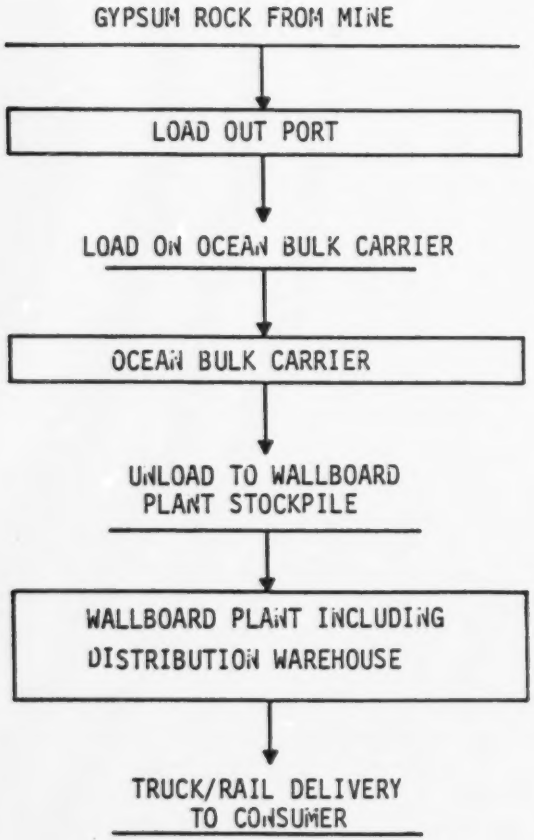
located at tide water in Nova Scotia immediately adjacent to the pier from which the company currently ships bulk rock to U.S. plants. Therefore, the proposed Nova Scotia plant will draw rock from the existing loadout stock pile and manufacture wallboard to be stored in its pierside warehouse for shipment.

Similarly, one can assume that the company's destination port warehouse is also adjacent to its loading/unloading pier where rock is normally unloaded. These assumptions are quite realistic; sites for such a plant do exist in Nova Scotia and terminal facilities either exist or could be established in the U.S.A. The proposed new system incorporating these assumptions is shown schematically in Figure III-4-1 along with the existing bulk rock transfer system.

For shipment of wallboard by sea to be cost competitive with bulk rock shipments two basic requirements must be met:

1. the <u>costs</u> of loading/unloading the board must be competitive with those that apply to the loading/unloading of bulk rock;
2. the loading/unloading <u>rates</u> in tons per hour of the ocean carrier must be the same as, or close to, that achieved for a bulk rock carrier.

It appears that the above conditions may be met if a RoRo vessel is used in dedicated service to move wallboard from origin warehouse to destination warehouse on heavy load, low height, trailers such as the MAFI trailer shown in figure III-4-2.(3) A RoRo vessel may be specifically designed for the purpose but basically it is a vessel whose hull has an opening through which it can be loaded with highway trailers. The signi-



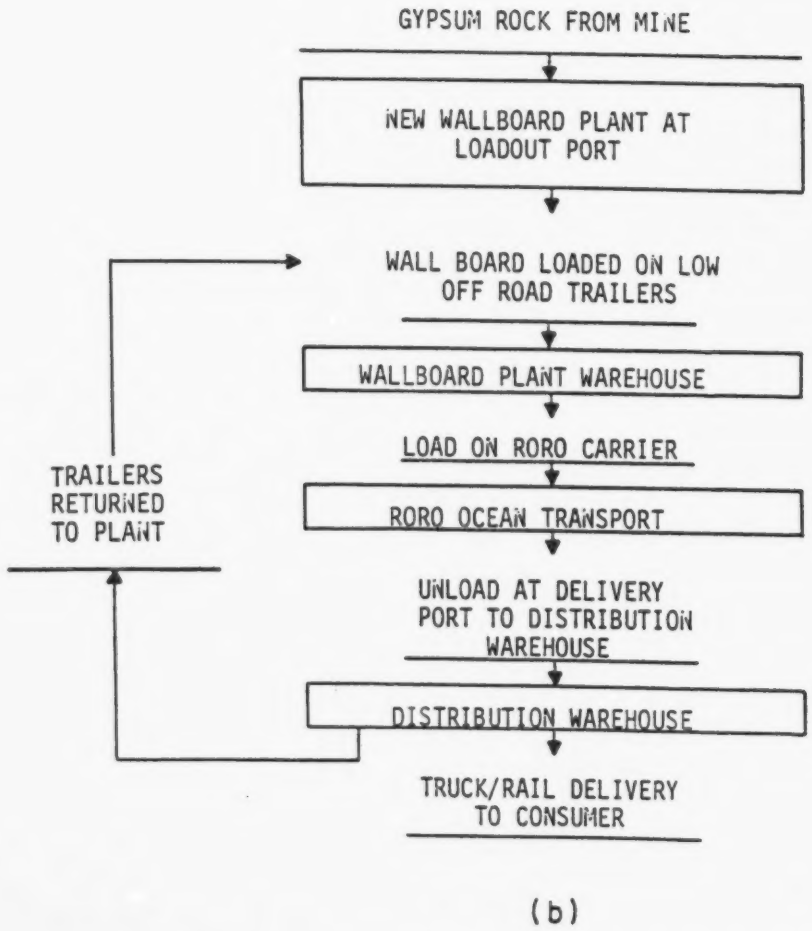

GYPSUM ROCK FROM MINE
NEW WALLBOARD PLANT AT LOADOUT PORT
WALL BOARD LOADED ON LOW OFF ROAD TRAILERS
WALLBOARD PLANT WAREHOUSE
LOAD ON RORO CARRIER
RORO OCEAN TRANSPORT
UNLOAD AT DELIVERY PORT TO DISTRIBUTION WAREHOUSE
DISTRIBUTION WAREHOUSE
TRUCK/RAIL DELIVERY TO CONSUMER
TRAILERS RETURNED TO PLANT
(b)

Figure III-4-1 Schematic Illustration of Current Rock Delivery/Wall Board System (a) and Proposed System (b)

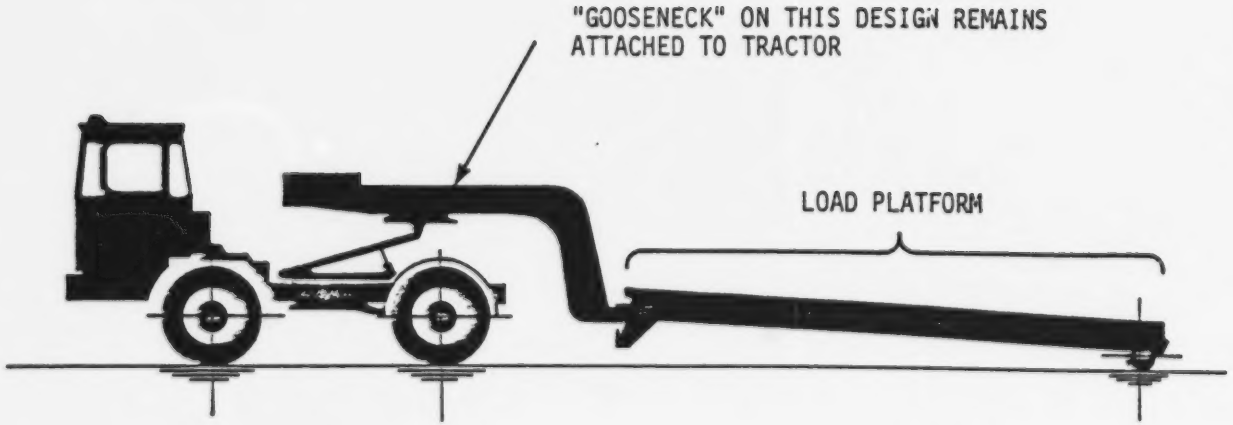


FIGURE III - 4 - 2 - SKETCH OF A "MAFI" TYPE TRAILER. LOAD PLATFORM LENGTH AS REQUIRED FOR 45-TON LOAD OF WALLBOARD APPROXIMATELY 33 FEET.

ficant feature is that trailers are 'rolled on' and 'rolled off'. The opening may be in the bow, the stern, or in the side. Car and rail ferries are special cases of RoRo vessels; currently the term is normally applied to ocean carriers that are trading primarily in automobile, trailer and container traffic.

The proposed trailers must be heavy-duty units designed for off-highway use only. They will have no brakes, no springs, no electrics and will be fitted with solid, fixed front-end legs. Trailers will be moved by a conventional tractor fitted with a liftable gooseneck, as illustrated, that permits the driver to pick up the front end of the trailer and move it over reasonably level ground at speeds up to 10 to 20 kilometres per hour. Trailers with decks nominally 9 feet by 33 feet would be loaded with 56 lifts of 4 foot by 8 foot by 1/2 inch wallboard with 3 inch dunnage between lifts as is customary for warehousing and shipping board. On that basis the load on the trailer will be in the range of 40 to 50 tons.

Although RoRo vessels are commonly used to move highway trailers from port to port, including transport of loads of wallboard to Carribean ports, they have not been used in dedicated service such as proposed here. At the same time no technical reason has been found yet to rule out such application. However, if a vessel is established for dedicated haulage of wallboard on trailers of the MAFI type, then the requirements set out above may be met.

The overall height of a MAFI trailer loaded as proposed will be about 13 feet, which is consistent with the heights of trailers now loaded regularly onto RoRo vessels. Moreover, for distances of a few hundred yards from warehouse to vessel and vessel to warehouse, RoRo trailers are commonly loaded or unloaded from RoRo vessels at rates of 40 to 50 per

hour by 2 tractors.(4) To assume that the proposed wallboard trailers can be loaded or unloaded at the rate of 20 per hour is conservative, yet such rates are consistent with the 1,000 tons per hour required in order to be at least competitive with loading rates of bulk rock.

For a vessel of a specific size to be loaded with the same tonnage of wallboard or rock, both the vessel size and its load must be reasonably consistent with the production rate of the wallboard plant and the distance to the distribution warehouses to be supplied. For present purposes, it is reasonable to assume that a Nova Scotia plant would be built to economic scale, probably in the size range capable of producing about 340,000,000 square feet per year of wallboard or about 300,000 tons. For mid- to southeast-coast U.S. deliveries, a voyage time of one week can be assumed for travel each way. A vessel load in the range of 15,000 tons is indicated which is in the tonnage range in use for bulk rock, albeit at the low end.

To estimate loading feasibility it can be assumed that trailers carrying 45 tons of board in lots occupying volumes 9 feet by 33 feet by 13 feet can be loaded 7 abreast and on 3 decks. The beam indicated by this pattern will be in excess of 63 feet but not likely greater than 75 feet which is consistent with a vessel in the anticipated tonnage class. The total length of the vessel can be projected from the requirement that three decks will contain 15,000 of tons of wallboard on trailers, or that about 333 trailers can be carried; the total deck length required is indicated as (333 x 33)/(3 x7) or approximately 525 feet. This length appears to be consistent with vessels in the anticipated size range.

In conclusion, a carrier in the tonnage range used for bulk rock can carry the desired volume of wallboard on schedules consistent with rock

movement rates. If it is assumed that loading and unloading will be at docks or piers that may also be used for rock loading or unloading, the arrangements in Figure III-4-3 illustrating a front-loading RoRo vessel and multiple-use piers appear reasonable. Minimum dock loading facilities will be necessary if rock is not to be handled at the same pier. In this case, it will require only a ramp and stable pilings to hold the bow and stern in place during loading or unloading.

This shipping system may require more warehouse area than a conventional plant distribution centre because the height of a load on a trailer is considerably lower than the height to which board can be stacked in a warehouse. However this requirement is less technical than financial and is a factor to be resolved along with inventory levels and other costs when a specific project is evaluated.

Finally, for a system moving 333 trailers per voyage, a total of about 1,000 trailers must be available. One set will be at sea, loaded or being returned unloaded, one set will be unloading at the distribution warehouse and another will be loading at the producing plant.

Section III-5 Costs

III-5(a) Mining

Capital requirements:

It is rarely, if ever, realistic to consider the investment required for an 'average' or 'typical' individual mine because, by nature, mines of all

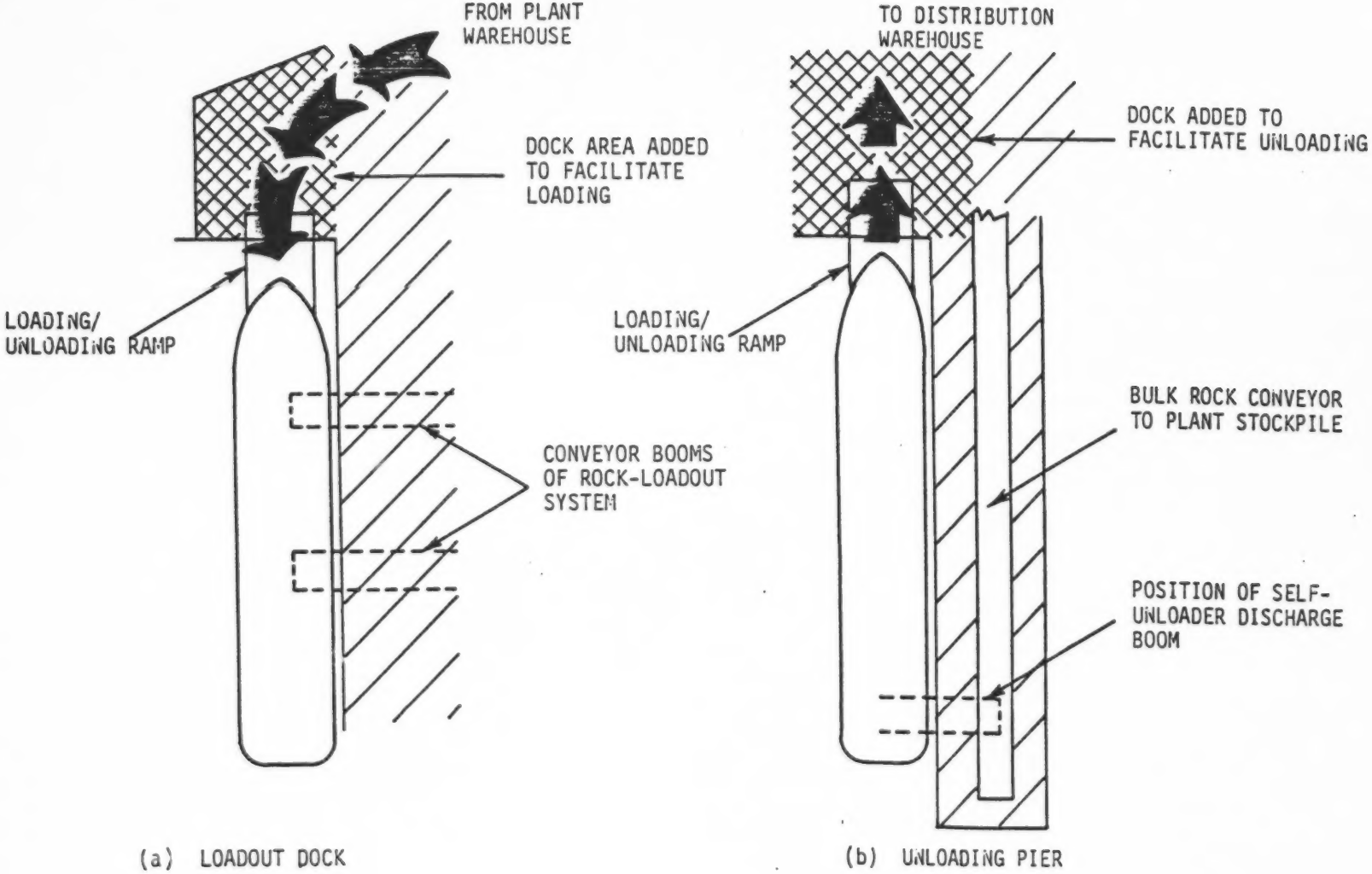

FROM PLANT WAREHOUSE
DOCK AREA ADDED TO FACILITATE LOADING
LOADING/ UNLOADING RAMP
CONVEYOR BOOMS OF ROCK-LOADOUT SYSTEM
(a) LOADOUT DOCK
TO DISTRIBUTION WAREHOUSE
DOCK ADDED TO FACILITATE UNLOADING
LOADING/ UNLOADING RAMP
BULK ROCK CONVEYOR TO PLANT STOCKPILE
POSITION OF SELF-UNLOADER DISCHARGE BOOM
(b) UNLOADING PIER

FIGURE III - 4 - 3 - DOCK/PIER ARRANGEMENT FOR PROPOSED RO RO WALLBOARD TRANSPORT SYSTEM

types are unique. New mines tend to involve as much infrastructure investment as direct mine investment, especially for more remote properties.

The investment requirements for gypsum mines, even with requirements for load out facilities, tend to fall on the low end of the investment spectrum for mines. They are not located in remote areas and much infrastructure can be expected to exist or to be reasonably available. On the other hand, the cost of a loadout facility can be independent of the size of a mine, while topographical features, shipping requirements, and so on can make development investments differ widely from property to property. As a result, only a broad range of investment levels can be indicated for these projects.

In general, it is unlikely that a new gypsum mine in Nova Scotia will be developed as a labour-intensive small operation, that it will be developed on tidewater, or that shipping and related development cost will be negligible. As a result, a total development cost for an open pit operation with a capacity of one million tons of gypsum per year can be expected to be in the range of 15 to 30 million dollars and to provide 50 to 100 jobs.

Operating Costs:

Operating costs for a gypsum mine can be estimated with more certainty than capital costs insofar as variable items are concerned, and they are not as likely to vary widely from mine to mine. Projections for current or anticipated Nova Scotia operations are summarized in Table III-5-A.

Labour costs for a gypsum property must range widely depending on the nature of the deposit and the equipment in use. A deposit that requires

Table III-5-A

ESTIMATED VARIABLE COSTS OF MINING AND DELIVERING GYPSUM TO TIDEWATER FOR A NEW NOVA SCOTIA MINE (1985)

Item	Estimated Cost $/Ton
Labour	1.00 - 2.00
Supplies	1.00 - 1.50
Transport	1.50 - 2.50
Total	3.50 - 5.00
Estimated Average	4.50
Total Export Value	6.80

extensive stripping, detailed cleaning of the surface, close control of boundaries for grade control within seams, or small-scale equipment will inevitably show low productivity as measured by the labour component of the costs. This is already clear in the gross productivity levels reported by Nova Scotia producers.

Principal supplies include explosives, fuel and repair parts and, of these, only the fuel component can be considered comparable for small mines. The explosives component in gypsum mining may be much smaller than for most mines, probably only about 25% or less of that required in hard rock mines. Gypsum is less abrasive than other rocks. In total, supply costs are lower than would be expected for pits and quarries generally.

Transport charges, most likely rail charges, are shown for a haul in the order of 15 to 25 miles at a cost of $0.10 per ton mile. This estimate is consistent with current rates for Nova Scotia operators. Obviously, this cost represents a major item for these operators and, as a cost not subject to much control, it is an understandable source of irritation and concern. However, the province of Nova Scotia has no formal role in setting these charges; the railways and the Canadian Transport Commission are the designated authorities.

The indicated total range is not the sum of the extremes because the labour and supply extreme are not likely to be concurrent. The estimated average is shown close to the upper limit because the combination of high productivity, good operating conditions, and short haulage are not reasonable forecasts; it is more reasonable to assume that if such combinations were possible, those properties would now be established mines.

The items not included in table III-5-A include several that are fundamental to any industry: depreciation, taxes, debt-service, and pro-

fits. However, their magnitude can be estimated and the results are significant. If a mine producing 1 million tons per year of rock from an investment of $20 million is assumed, the minimum annual charge for depreciation and debt-service must exceed $2 million per year or $2 per ton for the project to be financially justified. If an allowance is also provided for taxes (in lieu of royalties) and for profit, the conclusion is inescapable: a new gypsum mine in Nova Scotia is unlikely. Nevertheless, existing operations do not necessarily fall within the ranges projected here depending on their debt position and the state of their equipment. For them, the indicated margin of $2.30 per ton coupled with the desirability of a stable source of gypsum may well justify continued operation of existing mines.

It would be a major error to assume that this margin is a significant factor in the total industry costs. On the contrary, brief comparison of these costs with those of the other supplier nations in the light of ocean transport costs lead to the opposite conclusion. Shipments of Spanish rock now being delivered to the U.S.A. are reportedly originating in the Almeria area of Spain and are being shipped from the port of Carboneras. They might also come from mines in the Barcelona or Tarragona areas with shipments from the port of Tarragona.(5) In both cases, rock would be from open pit mines within ten to twenty miles of the port and for the Almeria area especially, rail haulage to the ports is claimed to be available. On that basis, a comparison of the estimates for Nova Scotia with those for Spanish operations are meaningful.

First, it is probable that Spanish labour costs will be lower than those for Nova Scotia because lower productivity and lower wage rates tend

to balance. Moreover, any remaining difference cannot be projected as large because labour represents only about a third of total costs. Even if the final costs are only half those forecast for Nova Scotia, the reduction in total product cost cannot exceed one dollar per ton.

Supply costs in Spain cannot be expected to be less than those projected for Nova Scotia until Spain becomes a member of the E.E.C. Until then, equipment parts which are a major component of operating costs will be imported through distribution systems that have no advantage over Nova Scotia. In addition, energy charges will be higher than those in Nova Scotia.

It is difficult to estimate rail transport costs in Spain because the extent to which such service is state-operated and subsidized is unknown. However, if no subsidy is assumed, it is not likely that the cost can be more than marginally lower than those in effect in Nova Scotia. In general, the major portion of the costs are comparable, including fuel and equipment.

In total, the estimated variable costs of mining and delivering gypsum to tidewater for Spanish mines are not likely to differ from those projected in Table III-5-A by more than one dollar per ton. Moreover, the Spanish export production has apparently increased in recent years so presumably a greater commitment of the margin to debt service or profit can be expected than for established Nova Scotia gypsum industries. No information is available with regard to other items such royalties, taxes and profits.

It would appear that the net market value of Spanish rock at tidewater is roughly equivalent to that of Nova Scotia rock (plus or minus one dollar per ton). Therefore, it is appropriate to compare the transporta-

tion costs for Spain and Nova Scotia as they affect the net cost of rock delivered to U.S. east coast ports. This is discussed later in the report in the section on ocean carriers.

Section III-5(b) Processing

Capital Requirements:

The foregoing examination has established that a Nova Scotia wallboard plant will require a significant level area on tidewater with reasonable harbour capability. It can be assumed in a first analysis that the existing docks at destination ports will be suitable with minor modifications to accommodate a front loading RoRo carrier although warehouse additions and inventory carrying costs might also be required. However, for the present analysis, the cost of such destination investments will be ignored on the basis that they will be site-specific requirements of the company developing a Nova Scotia plant and part of a total Nova Scotia plant project. Only the major Nova Scotia investment will be considered here, albeit with the recognition that it is only part of the total project cost.

In addition to a suitable site, a Nova Scotia plant will require modest electrical power supply, natural gas, road access and the usual community services. However, as these are all site specific or merely assumptions at this time, it is unrealistic to attempt to evaluate them. In any case, they are not costs that would be identified with a new wallboard plant except inside plant boundaries.

Land for a wallboard plant site is already available or can be obtained at miniminal cost. The National Gypsum Company, for example, presumably has enough land at its pier on the Bedford Basin to establish a plant without seeking additional property. It would be entirely practical for U.S. Gypsum to establish a suitable site on its property at Little Narrows on Cape Breton Island, and property in the Port Tupper - Port Hawkesbury area should be available and suitable for a plant for either Domtar or Georgia-Pacific, assuming that Domtar has or can obtain rock on Cape Breton Island.

The investment forecasts for a new plant are shown in both Canadian and U.S. currencies in Table III-5-B for a board machine rated at 225 feet per minute. It has been assumed that the equipment will be supplied by a U.S. manufacturer on an installed basis with duty free delivery, and that all other plant costs will be provided from Canadian sources, primarily by local suppliers.

Buildings of 250,000 to 350,000 square feet, depending on warehouse requirements, are estimated at $35 (Cdn) per square foot which is intended to allow for reasonable weather protection for the area. Some of this building will be three or more stories high to accommodate the cyclones and dust collection equipment associated with the calcining operation. The site and service charges are merely an allowance for preparation and installations from property boundaries to the buildings.

Trailer costs are included as part of plant costs because they are required for the proposed plant location and because by doing so the costs of ocean transport are more realistic. The estimate of $5,000 to $8,000 Canadian per trailer is intended to include provisions for load bracing and lashing for ocean transport.

Table III-5-B

PROJECTED INVESTMENT FOR A NOVA SCOTIA WALLBOARD PLANT
(225 feet/minute production, 340,000,000 square feet/year, ½ inch board, site and harbour purchase excluded)

Item	Cost Range (Millions)	
	$U.S.	$Canadian
Plant Equipment[1]	16-20	-
Buildings	-	9-11
Site & Services	-	5
Engineering/Management	-	5
Trailers	-	5-8
Sub Total	16-20	24-29
Approximate Totals[2]	35-43	44-54

[1] Turnkey supply and installation of equipment in constructed plant.
[2] Exchange at 1$Can = 0.8$U.S.

The total plant cost is higher than that which would be reported to apply to a greenfield U.S. plant in a prime location due to building cost differences and delivery cost differences. An ideal U.S. plant of the same scale would be expected to require an investment in the $U.S. 25 to 30 million range, plus site purchase.(6)

Operating Costs:

The estimated costs of producing wallboard in the proposed Nova Scotia plant are summarized in Table III-5-C with explanations for three calculated items noted. However, enlargement on a few other items may be useful.

First, energy is assumed to be gas brought ashore from Sable Island near the Strait of Canso with service to Cape Breton Island. The charge for energy at $5 per million BTUs is intended to be equivalent to the return available from gas delivered to the U.S.-Canadian border in New Brunswick. Only about 10% of the energy estimate represents electrical energy.

Additives and supplies are an estimate only and may be higher than average because it is possible that a Nova Scotia plant would be dedicated to the production of a special product such as a water resistant board. Similarily, the overhead charge is probably lower than it would be for a plant in a metropolitan market location because of lower requirements for security, shipping control and similar functions.

The major reasons for the difference between the total cost indicated here and the cost at existing plants are the cost of freight on paper from

Table III-5-C

ESTIMATED COST OF WALLBOARD PRODUCTION ($ CAN.) IN A NOVA SCOTIA PLANT (BASIS: 1000 SQUARE FEET ½ INCH BOARD ON BOARD VESSEL; EXCLUDES CAPITAL CHARGES/DEBT SERVICE)

Item	Estimated Cost
Rock[1]	6.6
Paper[2]	32.9
Energy	11
Additives/Supplies	7
Labour[3]	7.5
Manufacturing Overhead	3
Total	$68.0

[1] Rock at 90% Gypsum.
[2] Paper at 12.50/MSF Face, 10.40 MSF Back fob Thorold.
[3] 100 Employees @ $25,000/year/340,000 MSF

Thorold to Nova Scotia, and the lack of a freight charge on the rock. If the estimated total delivery charge as proposed later is taken as $11 per thousand square feet, then the cost of board manufactured in Nova Scotia and delivered to a U.S. warehouse is indicated to be under $80 per ton Canadian which is believed to be competitive with or lower than current net U.S. production costs.

One possibility not included in these estimates is that paper for a Nova Scotia plant will be supplied from a U.S. mill with delivery on the return voyage of the RoRo vessel. If such were practical the cost of board could be lowered by as much as $9 per thousand square feet. However that prospect will be company specific.

Section III-5-(c) Transportation

Rail:

Rail transportation in Canada comes under federal jurisdiction through the Canadian Transport Commission. Rail companies are authorized to charge for their services on the basis of variable cost, fixed costs, and value of goods. However, the scope for rate setting is wide and, in effect, rates are probably as high as the traffic will bear, or as high as the competition will permit. For Nova Scotia gypsum, there is no competitive alternative to rail haulage from mine to port.

Rates for movement of gypsum even in unit trains cannot be compared directly with haulage of similar low density bulk materials such as potash and coal. Basically, the short hauls and limited quantities make signifi-

cantly less than full-time use of crews and equipment. Whereas coal might move in trains of 100 or more cars, gypsum is being moved in trains of fewer than 50 cars, and not throughout the year. It follows that gypsum charges are unlikely to be comparable to charges for other unit train traffic since gypsum haulage gains none of the advantages of scale.

It is impractical here to evaluate rail charges; however it would be less than prudent for the industry to expect significant reductions from current levels on the basis of comparison with other unit train costs.

Ocean Carriers:

Capital requirements: it may be significant that numerous vessels in the size range considered for wallboard haulage are currently being offered for sale. Recent sales of vessels in this class have reportedly been at low prices.(2,7) It appears that a fairly recent vessel suitable for use in RoRo service may be available for less than $ 5,000,000 U.S. and convertible to RoRo service for an additional $10,000,000 or less. That indicates that for less than $15,000,000, a vessel with a life of 15 years may be available which would represent a considerably lower investment than the estimated $25,000,000 required for an entirely new Ro Ro vessel.

However, these prospects, though encouraging now, can only be considered as part of a total case analysis. It may also be practical to convert an existing company-owned carrier to RoRo service to serve a new plant and to replace it in rock transport by westbound backhaul capacity. If so, the benefits of both a Nova Scotia wallboard plant and lower freight costs may be achieved.

In any case, it appears that both technical and economic benefits may accrue from a Nova Scotia plant. Current U.S./Canadian currency exchange rates and the now-available tax advantages associated with a Cape Breton plant location also add to the desirability of an examination of the case by each Nova Scotia producer.

Operating Costs:

To appreciate the problems and opportunities that exist for the wallboard industry due to ocean freight charges, it is useful to examine first the minimum costs involved in simple movement of material in a carrier of the size involved. These are summarized in Table III-5-D.

The first item of Table III-5-D is the minimum charge for vessel ownership, an opportunity cost which assumes an original vessel cost of $25,000,000 U.S. which is written off over 330 days per year for 25 years at a nominal interest rate. This approach is used for minimum cost estimating because that situation is consistent with the availability of excess shipping capacity; in essence it is oriented toward the point at which a vessel is operated in preference to being moth-balled or sold.

The charge for crew, provisions, and operating service assumes operation under a flag of convenience. This cost would be in the range of U.S. $10,000 per day under Canadian or U.S. registration.

Fuel charges at sea assume 30 tons of bunker "C" fuel per day at $200 per ton plus 2 tons per day of diesel fuel at about $250 per ton; in port, only the diesel fuel would be consumed. These estimates also assume a vessel moving at 12 to 13 knots or about 300 miles per day. The indicated

Table III-5-D

OCEAN TRANSPORT COSTS FOR A BULK CARRIER - 20,000 DWT, SELF-LOADING CONVENIENCE REGISTRATION

Item	Daily Charge $U.S.	
	at Sea	in Port
Vessel	4,000	4,000
Crew, Provisions, Operating Service	4,000	4,000
Fuel	6,500	500
Total Costs	14,500	8,500

minimum cost of cargo movement at sea is about 0.0025 U.S. dollars per ton mile and it is noteworthy that this charge is not greatly affected by different approaches to the vessel cost. Also, the cost of moving the vessel in ballast differs little from that of moving it loaded as noted earlier.

The cost of port time is not so readily determined because harbour charges, tug service, pilots, and so on can also apply. However, if these are assumed not applicable in the calculation of minimum costs then the port time charges are about $8500 per day. For a single voyage, that includes one day each for loading and unloading, consistent with a minimum 1,000 ton per hour loading rate. The cost of loading/unloading the cargo amounts to 0.85 U.S. dollars per ton, and the total vessel transport charge for a shipment with no backhaul can be given by

$$[(0.005)\ (\text{distance, miles}) + 0.85]\ \text{U.S. \$/ton}$$

For a 1500 mile delivery distance the indicated minimum charge is $8.35 U.S. per ton.

This cost does not include the cost of operating either loadout facilities or receiving facilities as would be required to represent total stockpile to stockpile charges. Instead it is assumed that terminal charges are included in the mine operating costs at the origin and in plant operating costs at the destination.

The case for shipping gypsum from Spain to U.S. east ports can be examined now in the light of these estimates. First, it can be assumed that a vessel such as that used in developing Table III-5-D has discharged its cargo at a Mediterranean port and is returning westbound in ballast. The vessel will be encountering all of the travelling cost whether it car-

ries a cargo or not. The only costs of carrying a load of gypsum on the westbound trip are the costs of the time to divert to the loading port, of diversion to the unloading port, and the time to load and unload. If one day of diversion at each end of the voyage is assumed, the indicated minimum cost for the delivery is about $46,000 or about $2.30 U.S. per ton.

The indicated margin on the cost of delivery of Spanish rock over that of Nova Scotia rock to the same port is about $6.00 per ton. Therefore, if Spanish rock at tidewater is valued at or below the value of Nova Scotia rock at tidewater, scope exists for the carrier to negotiate a considerable benefit for carrying the Spanish rock while still undercutting the delivered value of the Nova Scotia product. Obviously, there is no prospect for cost reduction in Nova Scotia mines to compensate for that difference. Moreover, even if the carrier uses several days to unload using deck cranes, the additional cost of the port time amounts to less than $2 U.S. per ton delivered so the advantage to the Spanish rock is decreased but not eliminated. The situation does not require self-unloading carriers although the advantage for Spanish rock over Nova Scotia rock is greatest for vessels so equipped.

Nevertheless, it should be reasonable for Nova Scotia rock haulage to use westbound backhaul capacity. Shipping lanes from the Mediterranean pass close to Nova Scotia on route to U.S. east coast ports so that the same diversion, loading and unloading costs that apply to Spanish rock could also apply to Nova Scotia rock. If no further considerations apply, this would permit Nova Scotia producers to compete directly with Spanish sources.

However, this last prospect may not exist for Nova Scotia operations depending on the fraction of each company's production that is carried on

company-owned vessels. If all production is carried on such vessels then the cost of transport by backhauling must be increased by the costs associated with deactivated vessels. This cost would, presumably, include a vessel charge and moth-balling or similar costs, but these would apply continuously, not just to the time of the replacement voyage. On that basis, it is doubtful that replacement of owned vessels would be practical. Nevertheless, the difference between self-owned haulage and backhaul rates may justify scrapping of older owned carriers.

The case for moving wallboard by dedicated RoRo vessels can also be gauged at this point with two cost components to be considered: first the cost of loading and unloading and, second, the cost of ocean movement. The cost of loading and unloading can be estimated on a worst case basis as the cost of operating two tractors at each end of the voyage at the maximum applicable labour rates. That is, for a tractor cost of $25 per hour and an operator cost of $25 per hour, the charge for two machines to load and unload at a rate of 1,000 tons per hour will be $1.0 per ton. The cost of extra warehouse space and inventory might also be factored in against loading and unloading operations or assigned to the plant or to marketing. If a new plant and new distribution centre are involved, the costs of a trailer loading system may be less than those of rock loading and unloading at conventional terminals since the costs of rock-loading facilities will be avoided at one end of the shipment.

The total cost of ocean movement of wallboard by RoRo vessel will be identical to that of rock movement if identical vessel capabilities are involved. If the net loading of a specific vessel that would carry 20,000 tons of rock is limited to only, say, 15,000 tons of board, which appears to be the greatest mismatch that might develop, the cost effect can be set

by the ratio of the tonnages. If the cost per ton of hauling rock is $8.35 (U.S.) per ton, the cost per ton of wallboard will be $(8.35 x 20,000 / 15,000) or about $11.15 per ton. The differential of $2.80 per ton is clearly small enough to justify serious consideration of the new approach.

At the same time, it must be stressed that this apparently competitive new system for transporting wallboard is strictly speculative and will depend on individual project analysis. The most sensitive single feature will be the practicality of loading a RoRo vessel sufficiently to permit its ocean costs to match those for a bulk carrier. In addition, the integration of vessel movement into a manufacturing/delivery system has been assumed here but, in an actual case, many problems could arise. The claim that the system may be competitive is intended as an invitation to producers to make detailed evaluations.

Truck:

As pointed out earlier (see section III-4(c)) it is quite impractical to estimate costs of truck and rail delivery from a plant because of the many factors that can have an effect.

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Chapter IV POLITICAL AND OTHER CONCERNS

Section IV-1 Tariffs

Table IV-1-A is a summary of gypsum and gypsum product tariffs items for Canada and the United States. As can be seen, the MFN rates on wallboard entering Canada (applicable to imports from the USA) are two to three times the rates on wallboard moving from Canada to the USA. The MFN rates on gypsum wallboard entering the U.S. which apply to Canada are extremely low, offering little penalty when compared to the current currency differentials. In summary, the tariff structure and currency differential offer Canada significant protection while making export to the United States an economically attractive option.

Section IV-2 Non Tarriff Barriers

There are no significant non tarriff barriers in Canada/U.S. trade of gypsum or gypsum products. There are significant non tariff barriers to be considered however if shipment of wallboard to Western Europe or Japan is considered. Timber frame housing and gypsum wallboard finishing are not traditional housing construction methods in Western Europe. In France there are only two major wallboard manufacturers, one of which (Plâtres Lafarge) is a member of what constitutes an effective cement cartel in Western Europe. A third company (Escogypse) began production of wallboard in Northern France in 1982 after encountering strong opposition from the two large existing manufacturers. In the case of Japan, distance and large

Table IV-1-A

CANADA AND UNITED STATES - GYPSUM AND GYPSUM PRODUCTS TARIFF RATES

ENTERING CANADA

Tariff Item	Description	British Preferential Tariff	Most Favoured-Nation Tariff	General Tariff	General Preferential Tariff
19200-7	Gypsum wallboard	10.9 p.c.	10.9 p.c.	35 p.c.	Free
	on and after Jan. 1, 1986	10.1 p.c.	10.1 p.c.	35 p.c.	Free
	on and after Jan. 1, 1987	9.4 p.c.	9.4 p.c.	35 p.c.	Free

ENTERING UNITED STATES

Item	Description	MFN (applies to Canada)
512.21	Crude gypsum	free
512.24	Ground calcined per ton	48¢
245.7	Wallboard	3.8%

amounts of by-product gypsum make sales of North American manufactured wallboard unlikely.

In general, no difficulties are foreseen in relation to Canada/U.S. trade of gypsum and gypsum products. In the case of Western Europe and Japan, transportation costs, local production capabilities and the existence of cartels represent significant barriers to trade.

Chapter 5 MARKETING

Section V-1 Historical

Two events have had a major impact upon the use of gypsum as a construction material. The first was the discovery in 1885 of a commercially acceptable method of retarding the setting rate of gypsum plaster which permitted its large scale use as a construction plaster. The second event was the development of gypsum wallboard in 1918.

The discussion of the gypsum market will focus primarily on wallboard since it accounts for over 70% of total gypsum consumed in North America. In 1983, for example, total consumption of gypsum in the United States was 21,843,000 short tons of which 15,673,000 short tons were used in the production of wallboard (1). (Other principal uses are as a set retarder in cement, accounting for 18%, and as a soil conditioner in agriculture, accounting for 6%.) Statistics from the U.S. Bureau of Mines are used to describe the market in a current and historical context. This was considered a reasonable approach since the North American market is dominated by U.S. demand and any contemplated further processing of gypsum in Nova Scotia would be based upon satisfying a demand for wallboard in the U.S. market. A brief final section describes other gypsum and anhydrite markets.

Over the past fifty to sixty years, the total demand for gypsum has very much been a function of the health of the building construction industry. The traditional measure used to predict gypsum demand has been new housing starts. The demand for Nova Scotia gypsum, for example, fell to near zero after the 1929 stock market failure when new housing construction virtually stopped.

Table V-1-A shows total sales of gypsum wallboard in the United States over the period 1971 to 1984. According to a U.S. Bureau of Mines publication, the consumption of gypsum wallboard has exhibited an average annual growth rate of 3.2% over the past 21 years. No attempt was made to correlate sales and housing starts although informal discussions with officials of the Bureau of Mines in Washington confirmed this relationship.

Table V-1-B shows the average producer price in constant U.S. dollars per short ton of crude gypsum over the period 1971 to 1983 (1), illustrating the price per short ton has actually fallen over the period. The primary reason for this price decline, according to U.S. Bureau of Mines publications, is the impact of the large scale integrated operations which evolved during the 1960's.

Although the market has been dominated by a small number of relatively large firms, all available evidence suggests a high degree of competition. Distribution patterns have been varied with sales being direct from plant to large building contractors as well as through building product wholesalers to retail outlets. Common practice has been for larger contractors, building supply chain stores, or purchasing associations to go to tender on large wallboard purchases. Usually, once a chain or association had negotiated a price for wallboard, individual retail outlets were able to place orders directly with the manufacturer.

Table V-1-A

TOTAL U.S. SALES OF GYPSUM WALLBOARD, 1971-1984*

Year	Sales (million square meters)
1971	1,107
1972	1,331
1973	1,401
1974	1,182
1975	992
1976	1,200
1977	1,415
1978	1,518
1979	1,563
1980	1,310
1981	1,255
1982	1,209
1983	1,556
1984	1,695

*Source: Internal Documents, Bureau of Mines, U.S. Department of the Interior.

Table V-1-B

CONSTANT 1983 U.S. DOLLAR AVERAGE PRICE PER SHORT TON OF GYPSUM IN THE UNITED STATES, 1971-1983*

Year	Average Price	Constant 1983 Dollars
1971	3.75	8.42
1972	3.93	8.47
1973	4.18	8.53
1974	4.41	8.26
1975	4.58	7.85
1976	5.00	8.15
1977	5.55	8.55
1978	6.23	8.93
1979	6.83	9.01
1980	8.33	10.07
1981	8.53	9.43
1982	8.46	8.82
1983	7.87	7.87

*Source: Bulletin 675, Bureau of Mines, U.S. Department of the Interior, 1985.

Section V-2 Current Situation

Section V-2-1 Total Market Size

The current annual North American market for gypsum wallboard is approximately 1.8 billion square meters of which roughly 1.65 billion is in the United States and the remainder, 150 million square meters, is in Canada (1,2,3,4,5,6). Current annual production capacity in Canada is in the order of 200 million square meters, approximately 30% in excess of the annual domestic market demand. Capacity in the U.S. is roughly equal to demand.

An assessment of foreign markets was carried out using available trade statistics and the assistance of Canadian Trade Commissioners in selected locations. The Department of Regional Industrial Expansion has made a significant effort over the past fifteen years to promote the use of timber frame construction (to the standards included in the Canadian building code) in a number of countries in Europe, and in Japan and Korea. The primary objective of this effort was to promote the sale from Canada of dimensional lumber and related products such as kitchen cabinets. On the grounds that an expanding market for timber frame housing might also result in export sales of wallboard, it was judged worthwhile to investigate these markets. Table V-2-1-A includes an assessment of market size in each country as obtained from various U.N. trade statistics, discussions with officials of DRIE in Ottawa, and responses from questions directed to trade commissioners in selected overseas locations.

Two factors influencing the size and structure of the current market are residential housing repair and renovations and the increased use of

Table V-2-1-A

PRINCIPAL WALLBOARD STATISTICS - SELECTED COUNTRIES

Country	Annual Timber Frame Housing Starts	Current Annual Consumption of Wallboard (m^2 x 1,000,000)	Current Annual Production Capacity (m^2 x 1,000,000)
U.K.	50,000	N/A	N/A**
France	10,000	100	N/A
Germany	N/A	60	65
Japan	30,000*	450	N/A***

* Projection is for 100,000 timber frame starts by 1990. Total for Japan is 2,000,000 housing starts annually.

** British production capacity reported by Canadian officials in London to exceed domestic demand.

*** Japan does not import wallboard and capacity is at least equal to annual demand.

gypsum wallboard in commercial and institutional buildings. The total current annual expenditure on housing repairs and renovations in the U.S. is $60 billion and this market is growing at an annual rate of 12% according to a U.S. Gypsum Company publication (7). The mandated use of gypsum wallboard in commercial and institutional buildings, because of fire retardant characteristics, is primarily responsible for increased demand in that sector.

Section V-2-2 Margin Structure and Prices

Precise information on the margin structure used by individual firms proved to be difficult to obtain. Some conclusions on average values can be obtained, however, from published trade statistics and current selling prices. Average total cost of manufacturing reported to Statistics Canada per thousand square feet is in the order of $110.00. At a variable cost of $70.00 per thousand square feet as developed earlier, this implies that corporate overheads amount to approximately $40.00 per thousand square feet. Current selling prices to large contractors and chain stores in Central Ontario are in the order of $145.00 per thousand square feet, delivered. Thus, the manufacturers have a margin of approximately $35.00 per thousand square feet to cover federal sales tax, delivery charges (transportation) and profit. Current prices for smaller customers buying from building material suppliers in Toronto and Montreal are in the order of $180 to $190 per thousand square feet in truckload lots delivered to the job site.

It seems clear from the foregoing that the manufacturers are currently earning very little return on Canadian sales in Central Ontario. It is not known whether this situation is mirrored in other regions of Canada.

Sales to the United States appear to be more profitable when prices in the Philadelphia area (a major destination for Canadian wallboard) are examined. Current prices there are in the order of $195.00 (U.S.) per thousand square feet in truckload lots delivered to the job site. If building materials suppliers there operate with the same mark-ups as their Canadian counterparts, this would suggest a price to the manufacuturer of approximately $150.00 (U.S.) per thousand square feet. At $.75 (Cdn) this figure translates to $200.00 per thousand square feet. Export statistics show current declared values for wallboard entering the U.S. to be $128.00 per thousand square feet, including all taxes and transportation costs to the border crossing point. After paying the 3.8% duty the total cost to the manufacturer is in the order of $135 per thousand square feet. Thus, the manufacturer is left with $65.00 per thousand square feet with which to pay transportation to Philadelphia and from which profit may be taken. Clearly, the U.S. market currently appears more profitable than does the Canadian market.

Examination of Canadian price indices for gypsum products provides some interesting implications for Nova Scotia. Table V-2-2-A shows price indices for total gypsum products and for wallboard alone. For wallboard alone, the indices are shown for Ontario and for the rest of Canada. It is noteworthy that prices have increased substantially since 1981, and that a price advantage for wallboard that existed in Ontario in 1981 appears to have disappeared by April of 1985.

Table V-2-2-A

PRICE INDICES FOR GYPSUM PRODUCTS

Total Gypsum Products

Year	Price Index
1981	226
1982	232
1983	251
1984	271
1985	278, 284, 285, 287

Wallboard

Year	Price Index for Ontario	Price Index for Rest of Canada
1981	205	223
1982	214	229
1983	236	247
1984	257	273
1985	268, 279, 279, 280	278, 284, 285, 280*

*Figures are by month for first four months of 1985.

Source: Statistics Canada Catalogue 62-011 Monthly.

Section V-2-3 Major Firms

There are four large wallboard manufacturers in Canada. Two of these, Domtar and Genstar, are Canadian owned while the other two are foreign owned, Canadian Gypsum by U.S. Gypsum and Westroc Industries by British Plaster Boards Limited.

The major firms manufacturing gypsum wallboard in the United States are U.S. Gypsum (22 plants), National Gypsum (18 plants), Georgia-Pacific (9 plants) and Genstar Building Materials (5 plants).

Section V-2-4 Distribution Structure

As the North American retail market for building materials becomes increasingly dominated by large building supply chain stores, the number of customers with whom the wallboard manufacturers must transact business is reduced. This has a simplifying effect upon the distribution of gypsum wallboard. All manufacturers contacted confirm that they operate their own distribution systems to some degree. The majority of wallboard is sold directly to large building contractors or retail chains. Building supply wholesalers are used but do not represent a major portion of sales.

The distribution structure is clearly dominated by transportation costs. An assumed road transportation cost of $.15 per ton mile reduces a $35 per ton margin to zero after 230 miles. Discussions with the major manufacturers in the U.S. confirmed that plants must be situated within 200 miles of the markets if road transport is to be the means of delivery.

Information received from Europe suggests that distribution structures there are similar to those in North America but are further complicated by the cartel noted earlier in the report.

Section V-2-5 Consumption Patterns

Historically the major market for gypsum wallboard has been new construction. The market for wallboard for use in retrofits or renovations has increased in recent years, and is growing at an annual rate of 12%. In many parts of western Europe where gypsum block walls are a traditional construction method, the renovation market is being dominated by timber frame and wallboard construction because the associated electrical and plumbing work is much simpler. Discussions with marketing personnel of wallboard manufacturers confirm the emergence of the renovation market as a major factor and expectations are that it will remain so for the medium term at least. All but one of the major wallboard manufacturing firms agreed that they were facing a market which will exhibit little growth in the future.

Examination of U.S. consumption statistics reveals the emergence of a number of specialty wallboard products over the past few years. Three of these, 5/16 inch wallboard used in mobile homes, type X wallboard and water resistant wallboard, accounted for 35% of all U.S. wallboard sales in the first two months of 1985.

Given expectations of a 'no-growth' or shrinking total market, the trend toward product differentiation can be expected to continue or accelerate. None of the personnel in firms with whom discussions were held

discussed new product development, but all were clearly interested in the subject.

The U.S. market currently represents an important segment from the standpoint of the Canadian manufacturers. It seems clear that maintaining a strong position in this market is highly dependent upon the currency exchange rate. Current rates of exchange offer great advantage to Canadian manufacturers. In 1983, shipments of gypsum wallboard to the U.S. totalled 26 million square meters and this figure rose to 72.3 million square meters in 1984. This latter figure represents approximately 35% of total Canadian capacity. Since Canadian shipments to the U.S. amount to less than 5% of that country's annual consumption, it is not likely that the tariff rate will be changed.

Section V-3 The Future

As noted above, the market for gypsum wallboard is perceived by all but one of the major manufacturers to have reached maximum size and is predicted to remain stable or begin to decline in the next five to ten years. No new substitute products that could have the effect of further reducing market size were identified and as such, increasing price competition can be expected. If the Canadian dollar remains in the range of $.70 to $.75 (U.S.), Canadian firms exporting to the U.S. could retain a significant advantage.

It is noteworthy that the message by the Chairman of U.S. Gypsum delivered to a management conference in 1984 included the statement that the goal of the firm, increasing shareholder wealth, would be achieved

through 'acquisition or start up of new businesses, emphasis on research and development, obtaining a larger return on investment from current businesses and maintaining our strong financial condition'. It is probably not accidental that in this statement, mention of the acquisitions of new businesses preceeded mention of existing ones.

The future health of the Canadian wallboard manufacturing industry appears to be contingent upon both a continuing exchange rate of $.70 to $.75 per U.S. dollar and a continuing low tariff (3.8%) on the entry of wallboard into the U.S.

Section V-4 Other Gypsum/Anhydrite Markets

It was pointed out earlier that gypsum is effective in wallboard manufacture because of its ease of calcination and rehydration. For uses where those features are not required, gypsum and anhydrite may be interchangeable or replaced with chemical gypsums. Moreover, the quality restrictions that apply to gypsum for wallboard manufacture are more stringent than for other uses for which non-conventional or chemical gypsum is more likely to be accepted.

Since 1979, the pattern of uses has changed little. Gypsum and anhydrite consumption in portland cement may have increased slightly but such changes cause no significant shift to other sources or traffic. In addition, significant efforts have been made to develop new outlets by the Florida Institute of Phosphate Research and by organizations concerned with the recovery and disposal of sulphur from flue gases.

The Florida Institute has also developed several products including tiles, building pads and road applications that have significant poten-

tial, particularly for warmer climates. The fact that sulphur has been produced from gypsum makes it difficult to eliminate gypsum as a source of sulphur though the supply of sulphur from sour gas treatment is likely to command that market for some time. More important for Nova Scotia, however, is the fact that these products will not require Nova Scotia rock; they will be produced from lower grade local products, probably chemical gypsums.

One outlet for anhydrite, not considered in 1979, is its use as a roof support material in longwall coal mining. The scale of this market is not clear yet, although commercial systems are in use in the U.K. and elsewhere(10), and the Cape Breton Coal Research Laboratories of CANMET are evaluating its potential for Canadian applications. However, the prospects for Nova Scotia rock are unlikely to be expanded greatly by this application since chemical gypsum can be used.

Gypsum consumption figures for Canada were obtained from officials at Statistics Canada and they closely reflect patterns in the United States. Roughly 72% of gypsum consumed in Canada goes to the production of wallboard and related products, 26% is used as a set regulator in cement manufacturing and the remainder is used in a number of small applications. Since most of Nova Scotia's production is exported to the U.S. and is used there in wallboard, changes in these other markets are unlikely to affect demand for Nova Scotia's gypsum. On the other hand, for reasons noted above, these markets are unlikely to result in new demand or uses for Nova Scotia gypsum.

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Chapter 6 OVERVIEWS AND SENSITIVITIES

Section VI-1 Structural Implications

World markets for gypsum and gypsum products appear to be dominated by a relatively small number of large manufacturers. These manufacturers are integrated vertically, owning the gypsum resources, the transportation equipment, the manufacturing facilities for both paper and wallboard, and the distribution network. In North America the industry is highly competitive while such does not appear to be the case in Western Europe.

There appears to be nothing which makes Nova Scotia unique as a supplier of gypsum and it will be important to remain competitive with offshore sources if current employment levels in the industry are to be maintained.

Because of the integrated nature of the industry, any expansion of the activity in Nova Scotia would almost certainly have to be an initiative taken by one of the existing companies in the industry.

Section VI-2 Technological Implications

Regardless of the size of a wallboard plant, the labour cost is a relatively fixed item. Because of this the minimum capacity that makes economic sense is in the order of 32 million square meters per year (340 million square feet per year), an amount which far exceeds demand in Atlantic Canada, making export markets mandatory to support such a facility.

By-product gypsum (phosphogypsum or flue gas desulphurization gypsum) is unlikely to supplant natural gypsum in wallboard production, except in a small way. The reasons for this stem from various impurities which occur in by-product gypsum and from other physical characteristics such as particle size.

From a technological standpoint, Nova Scotia once again has no unique advantage.

Section VI-3 Market Implications

If road transportation is to be used, a wallboard plant can normally be competitive within a radius of approximately 200 miles. Because of the size of unit sales and the dispersed nature of the market, road transport is the normal mode of transportation.

Canadian wallboard manufacturing capacity exceeds national consumption by over 30%. Thus any new plant must be built only if it can rely upon export sales almost exclusively.

Because of Nova Scotia's location on tidewater and its proximity to the large market in the eastern United States, it may have a unique advantage if a means to transport wallboard efficiently by sea can be found. This advantage appears magnified now because of current exchange rates.

A wallboard plant in Nova Scotia coupled with an efficient sea shipment system may be attractive too because it effectively allows whichever company that builds it to add capacity at little cost to any existing plant on tidewater. New capacity can be added simply by building a warehouse and pier, without the need to establish a manufacturing system.

Chapter 7 CONCLUSIONS AND RECOMMENDATIONS

VII-1 Commodity Supply

Conclusion

Although Nova Scotia gypsum is of high quality and near ocean points, Nova Scotia does not enjoy a unique position in regard to the supply of raw gypsum to the United States. Spanish gypsum is of equal quality and price and the availability of extremely low cost "back-haul" transportation from Spain make gypsum from that country highly competitive on the eastern seaboard of the United States. Any increase in the price of gypsum from Nova Scotia could result in the substitution of gypsum obtained in Spain.

Recommendation

The Government of Nova Scotia must ensure that nothing within its jurisdiction is done that could have the effect of increasing the price of gypsum to the existing users. Furthermore, the Government of Nova Scotia may wish to consider working with those firms mining gypsum in Nova Scotia to identify areas where it can help to reduce costs or prevent increases.

VII-2 By-Product Gypsum

Conclusion

By-product gypsum is unlikely to pose a threat to natural gypsum in the production of gypsum wallboard. Phosphogypsum is unsuitable because of dissolved salts, radioactivity and certain physical characteristics (grain size). Flue gas delsulphurization gypsum is unsuitable because of the presence of chloride. In the case of both phosphogypsum and flue gas desulphurization gypsum, the additional costs of treating the products to make them suitable for gypsum wallboard production exceed the costs associated with producing the natural product. Any decision to use by-product gypsum as other than a minority additive to natural gypsum in making wallboard will be based on other than economic considerations.

Recommendation

The Government of Nova Scotia need take no action in regard to by-product gypsum.

VII-3 Future Demand for Nova Scotia Gypsum

Conclusion

Nova Scotia gypsum is used almost exclusively in the production of gypsum wallboard, a commodity whose demand is tied to population demographics and

housing starts. The overall demand for gypsum from Nova Scotia is not expected to increase in the future.

Recommendation

Future emphasis must be placed upon keeping the costs of producing gypsum down and upon protecting existing markets.

VII-4 Increased Employment

Conclusion

The prospect for increased employment from the gypsum industry in Nova Scotia is tied to the establishment of a gypsum wallboard facility in the province. Two conditions must be met if a wallboard facility is to be established in Nova Scotia: first, it must be owned and operated by one of the existing wallboard manufacturers which already has a distribution system in place and is seeking to expand its market share or replace outdated or uneconomic production facilities; and second, a method must be found of transporting finished wallboard at a cost per ton that is equivalent to that of transporting bulk gypsum. Such a method is proposed in the report but final feasibility must be based upon individual corporate analyses using corporate data unavailable to the authors.

Recommendation

It is recommended that the Government of Nova Scotia make the companies which are already active in the Nova Scotia gypsum industry aware of the findings of this report, particularly regarding the use of RoRo vessels and MAFI trailers to transport gypsum wallboard.

VII-5 Specialty Products

Conclusion

Increased competition in the wallboard market appears to be causing some product differentiation. The emergence of such specialty products as water resistant wallboard could provide increased impetus for the establishment of a wallboard production facility in Nova Scotia. If a satisfactory transportation system is found, specialty wallboard could be landed competitively all along the eastern seaboard and not only within 300 kilometers of U.S. based production facilities.

Recommendation

In any discussions with wallboard manufacturers, the role of specialty products as a further argument supporting the establishment of a production facility should be included.

VII-6 Other Markets

Conclusion

Although both Europe and Japan consume large amounts of gypsum wallboard, neither market represents an opportunity for Nova Scotia. Transportation and distribution costs and other non-tariff barriers effectively exclude them from consideration.

Recommendation

No consideration should be given to markets other than the USA and Canada.